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REPORT OF THE CHIEF OF THE BUREAU OF ENTOMOLOGY, 1933

UNITED STATES DEPARTMENT OF AGRICULTURE,
BUREAU OF ENTOMOLOGY,
Washington, D.C., September 23, 1933.

SIR: I submit herewith a report of the work of the Bureau of Entomology for the fiscal year ended June 30, 1933.

Respectfully,

C. L. MARLATT, *Chief.*

Hon. HENRY A. WALLACE,
Secretary of Agriculture.

GENERAL

APPROPRIATIONS AND EXPENDITURES

The appropriation made to the Bureau for the fiscal year 1933 was \$2,471,700. In addition to this, \$55,000 was reappropriated from the unexpended balance of the appropriation made in 1931 for work on the Mediterranean fruit fly, bringing the total available to \$2,526,700. This amount is \$392,040 less than that available for the fiscal year 1932. Approximately one half of this difference represents reductions applied uniformly through the service in accordance with the Economy Act. Changes in the allotments for certain lines of work account for the remainder. Included in the latter are reductions made following recommendations from the Bureau that certain activities, such as the large-scale bait-trapping work on the oriental fruit moth, investigations on the blueberry maggot in Maine, and control of the Mormon cricket in Colorado, be discontinued. Small reductions in the allotments for work on the Japanese beetle and the European corn borer also contribute to the total. A large part of the reduction (\$155,395) was made when the appropriation bill was considered by the Senate and applied to the following three appropriation items: Fruit and shade tree insects, \$47,645; cotton insects, \$72,820; and taxonomy and interrelations of insects, \$34,930. The appropriation for the fiscal year 1933 did not provide funds with which to initiate new investigations or enlarge those under way.

Complying with the general administrative program, an effort was made throughout the year so to direct the work as to effect such additional economies in expenditures as could be made without seriously interfering with essential work under way. This policy and the cooperative effort of the Bureau employees effected savings in available funds totaling \$417,200, or approximately 16 percent.

CHANGES IN PERSONNEL

On February 13, 1933, D. L. Van Dine was appointed chief of the Division of Fruit and Shade Tree Insects, filling the position made vacant December 31, 1931, by the resignation of A. L. Quaintance. Mr. Van Dine's wide experience in economic entomology over a period of 31 years was fully set forth in Department publications at the time of his appointment. This experience has covered experiment station work in Hawaii, Puerto Rico, and Cuba and research work in connection with this Bureau in various fields as well as valuable experience in the World War in charge of insect sanitation.

POSSIBILITY OF FULL-SEASON RECORDS

The results of much of the experimental work of the Bureau dealing with the pests of crops maturing in the late summer and fall can be determined with accuracy only after the crop has ripened and usually in connection with its harvesting. This applies particularly to plot and field tests concerning such major pests as the European corn borer, bollweevil, and codling moth, and also the general subject of poisonous residues applying to many fruit and vegetable crops. Similarly, the important phase of carry-over and outlook for the next season as to these and other pests can be determined only late in the season. It follows that reports of most crop pests prepared in August or even in early September must be based, in large part, on the final records of crops and conditions of the previous season. With the object of making future reports reflect more accurately the results of the current season, the idea has been presented, with favorable reception, to the Director of Information that steps be taken to secure legislation permitting the deferment of such reports to the end of October. This report summarizes the results of work up to the middle of September.

CLIMATIC CONTROL

The importance of climatic control, as related to a number of the major insect pests, was emphasized during the year. Such control has resulted from low winter temperatures and from conditions unfavorable to insects during spring and summer, involving heat and cold, moisture and drought. These experiences indicate that climatic factors may be vastly more important than natural controls through parasites, or control by artificial means. The notable examples of such climatic action during the past year are itemized below:

Prolonged periods of intense cold, involving temperatures of -20° to -50° F., led to a destruction in Oregon, Washington, northern California, and in the forests of the northern Rocky Mountains of from 25 to 92 percent of the overwintering broods of bark beetles. This destruction has made it possible to abandon various control projects that had been planned and to discontinue others that were under way, and is undoubtedly a type of control which, in past ages, has been one of the principal factors in maintaining a balance between forest growth and insect pests.

The European corn borer made a notable increase in the western area during the season of 1932, with corresponding heavy population of larvae entering hibernation and successfully overwintering. This fully justified the prediction last spring of a great increase in borers and damage for the season of 1933. Throughout this western area, however, the late spring and early summer conditions of rain and cold were thoroughly unfavorable to the early planting of corn, with result that when the moths emerged, as they did in great numbers, the corn was too small to be attractive and such egg laying as later took place came at a period of unusually hot, dry weather, resulting in the destruction of many of the egg masses. While it is still too early to get the exact records, the present indications point to no increase of this pest.

The hessian fly, from fall and winter conditions, threatened unusual damage in wheat-growing areas east of the Rocky Mountains and warnings to that effect were distributed. The drought and heat of the early summer, however, gave this pest such an effective setback as to eliminate injury to the crop and also any danger of a general outbreak thereof in the near future.

In the case of the pea weevil in the very important Palouse area of Washington and Idaho, the low temperatures of the winter of 1932-33 caused such high mortality among hibernating weevils as to leave the crop of 1933 relatively free from damage.

At the opening of the season the bollweevil threatened very heavy crop damage on the basis of the unusually large number of weevils entering hibernation and the very considerable weevil survival into the spring of 1933. The excessive drought and heat in June and July over much of the Cotton Belt greatly checked weevil development, with result that only spotted weevil infestation has been experienced.

The reverse of the above is presented by the chinch bug. That this native pest is particularly favored by drought conditions has long been known, and this was demonstrated this year by its notable increase along with the drought in Iowa, Kansas, Missouri, and Indiana, together with unusual instances of injury in the eastern area—Pennsylvania, New York, and Vermont.

EXCHANGE OF USEFUL INSECTS

Note should have been made in last year's report of the assignment of Curtis P. Clausen to the duty of aiding the Chief of Bureau in coordinating the work of the Bureau and of the several States in the importation and distribution of beneficial insects. In this position he is responsible directly to the Chief of Bureau and will aid the Chief in the administration, in cooperation with the Bureau of Plant Quarantine, of the Insect Pest Act of 1905. Mr. Clausen's wide knowledge of parasitic and other beneficial insects, and especially his own extended and varied participation in and direction of their importation and colonization, well qualify him to fill this position. In the fall of 1932 the field station in Japan was made headquarters for all the Bureau's activities in the Orient on parasitic and predacious insects, and the direction from Washington of this field work was assigned to Mr. Clausen.

Under this arrangement the various divisional laboratories will continue to receive, study, and colonize in this country natural enemies which may be imported to aid in controlling various introduced pests. Information as to such importations and colonizations will be found in the reports of the several divisions.

In response to requests, parasites of important crop pests were sent to 3 dominions and 1 colony of the British Empire and to 6 other foreign countries during the year. Shipments of the egg parasite *Trichogramma minutum* Riley were made to Canada and Germany. Two parasites of the oriental fruit moth, *Diocetes molestae* Uch. and *Trichogramma euproctidis* Gir., were sent to Argentina. *Glypta rufiscutellaris* Cress. and *Pristomerus ocellatus* Cush., two American parasites of the oriental fruit moth, were forwarded to Japan. *Macrocentrus ancyliivorus* Rohwer, the most useful American parasite of the oriental fruit moth, was sent to Italy. Parasites of the Mediterranean fruit fly were sent to Australia, the consignments including representatives of four important species—*Diachasma fullawayi* Silv., *D. tryoni* Cam., *Opius humilis* Silv., and *Tetrastichus giffardianus* Silv. Two of the opiine fruit-fly parasites, *Diachasma tryoni* Cam. and *O. humilis*, well established in Hawaii, were sent to Spain. A consignment of *Phanerotoma tibialis* Hald., an important parasite of the codling moth, was sent to New Zealand. *Aphelinus mali* Hald., a parasite of the woolly apple aphid, was sent to Ecuador and a shipment of *Compsilura concinnata* Meig. was sent to Barbados.

Adults of three of the Mediterranean fruit fly parasites, *Diachasma tryoni*, *Opius humilis*, and *Tetrastichus giffardianus*, were sent to California for possible use on the walnut fly, *Rhagoletis completa* Cress.

FRUIT AND SHADE TREE INSECTS

Mention was made earlier in this report of the appointment of D. L. Van Dine as Chief of this Division, effective February 13, 1933.

APPLE INSECTS

CODLING MOTH

Infestation by the codling moth in many eastern and middle-western areas during 1933 has been the most severe that has been reported in the past 10 years. In the Pacific Northwest the infestation has been nearly as serious as in 1932. Contributing factors have been uncertainty as to the spray program and the abandonment of an increasing number of orchards. If the season had not been unusually late, the situation would have been even more serious.

The codling-moth problem has assumed an even greater importance than hitherto, owing to the increasing appreciation of the potential danger to human health of the presence of even minute quantities of lead as well as arsenic on food products.

The ratio of lead to arsenic trioxide in commercial lead arsenate is very close to 2 to 1. It appears that the arsenic often weathers off more rapidly than does the lead, and in some cases the quantity of the latter present at harvest time has been three or four times that of arsenic. Also, certain of the common alkaline washing solutions fail to remove the lead, although these have been effective in the removal of arsenic from apples under the conditions of increased adherence resulting from spraying with lead arsenate in combination with oil emulsions, or from apples which have developed excessive quantities of wax.

The lead tolerance established by the Department (announced April 2 as 0.014 grain of lead (Pb) per pound of fruit, increased June 20 to 0.02 grain of lead (Pb) per pound) has necessitated modifications of the Bureau's former recommendations for codling-moth control. Statements have been sent to State and experiment station entomologists, outlining the situation and giving them all available information as to other materials which might be used, particularly in the later part of the spray schedule. Unfortunately, fully satisfactory substitutes for lead arsenate are not yet available and in many sections of the country it is extremely difficult to control the insect and yet meet the requirements as to residue.

In the Pacific Northwest a combination of oil with nicotine sulphate appears to be fully as effective as lead arsenate in the later applications, although the greater cost of this mixture has had a tendency to restrict its use. After the announcement of a fluorine tolerance on June 20, certain fluorine compounds, particularly cryolite, have been recommended for the Pacific Northwest, where they have been found effective in codling-moth control. Excessive residues from sprays of these materials must, of course, be removed. Certain nonlead arsenicals, particularly calcium arsenate, have been suggested as possible substitutes, although they are less effective than lead arsenate and more likely to injure foliage. Greater emphasis has been placed on certain control measures hitherto considered supplementary in nature. These include banding, especially the use of chemically treated bands, and general orchard and packing-shed sanitation.

The ultimate solution of this problem is elimination of lead arsenate from the greater part of the spray schedule. The task of discovering or developing adequate substitutes for lead arsenate is being carried on by the Bureau of Entomology in cooperation with other bureaus of the Department, as well as with many of the State experiment stations. Although the substitute materials already mentioned are useful under certain conditions, the finding of a generally practical substitute for lead arsenate is proving a difficult task.

Because of the position taken by the Department in the spring of 1933 regarding residues of fluorine, no experiments were planned with the fluorine compounds, with the exception of certain small plots included in the Yakima, Wash., outline, to provide material for experiments in the removal of fluorine residues. In these field plots cryolite has appeared to be the equal of lead arsenate in codling-moth control. With the announcement of a fluorine tolerance, field experiments against the second brood were undertaken at Vincennes, Ind., with barium fluosilicate and cryolite, in combination with summer oils. Preliminary reports indicate that these materials are giving a fair degree of control, although cryolite has caused serious injury to fruit of the Golden Delicious variety.

Nicotine sulphate with oil emulsion, following early season applications of lead arsenate, has given effective control in the Pacific Northwest, and reasonably good results in Arkansas and Indiana.

Nicotine tannate, which has shown a great deal of promise in experiments conducted by the New Jersey Agricultural Experiment Station, has caused more or less injury to fruit and foliage in 2 of the 3 experiments conducted by the Bureau, and has not been found particularly effective in codling-moth control. The injury may have resulted from the combination of some ingredient of the nicotine tannate with arsenic which persisted on the trees from previous applications of lead arsenate or calcium arsenate.

The chemically treated bands developed several years ago by workers of the Bureau of Entomology are rapidly coming into commercial use, and appear to be of considerable value in reducing infestations, thus improving the control obtained, or reducing the amount of spraying that is necessary, and lessening the residue load at harvest time. The experiments the past season have shown that a 2-inch band captures nearly as many worms as a band 4 inches in width. Improvements have been made in the methods of treating bands, and a great many growers have prepared their own. The bands placed on the market by manufacturers have shown a steady improvement. Further attention is being given to the possible use of bait traps in controlling the codling moth. These capture large numbers of moths, but thus far their use has been chiefly as indicators of the periods during which the moths were active, as a guide to the timing of spray applications. The possibilities for their use in direct control are now being explored further.

In cooperation with the Georgia State entomologist's office, experiments are being conducted at Cornelia, Ga., with the utilization of the egg parasite

Trichogramma minutum Riley. The results of these experiments will be reported at a later date.

THE TARNISHED PLANT BUG

Further attempts to control the tarnished plant bug in orchards by means of insecticides have given discouraging results, and a careful study is now being made of host-plant relations. This insect breeds and feeds during most of the year on cover crops or weeds in and close to the orchard, and its attack on the fruit is restricted to a brief period in early spring. It is hoped that some adjustment of cover-crop practice may be worked out which will minimize injury by this insect.

OTHER APPLE INSECTS

Work on the relation of insects to the perennial-canker disease of apple has been continued at the Wenatchee (Wash.) laboratory. At the close of the period of canker extension in early June 1933 it was evident that there was a rather general extension of individual cankers.

In all cases where cankers had been cleaned out and the woolly apple aphid excluded thereafter, perfectly healthy calluses were invariably found. Where the woolly aphids had gained entrance to the cankers, however, there was in all cases a great amount of extension. A similar association of the "die-back" of the calluses with previous injury by woolly aphids has been indicated by numerous records of unprotected calluses kept under frequent observation. The woolly apple aphid is therefore an important factor, and may even be exclusively responsible for the extension of the perennial cankers. The elimination of this insect therefore appears to be important in controlling the disease. This has been found possible by the use of a number of canker paints consisting of nicotine sulphate with 7 to 20 percent of nondrying or slowly drying oils, such as castor oil, sperm oil, or cottonseed oil.

The aphid parasite *Aphelinus mali* Hald., which was introduced into the Wenatchee district 2 years ago, is now well established in the orchard in which the liberations were made and in nearby properties. The parasite is expected to become an important factor in keeping the woolly-aphid population within bounds.

PEACH INSECTS

PLUM CURCULIO

The plum curculio continues to be a major peach problem and is under investigation by the laboratories at Fort Valley, Ga., and Harriman, Tenn. The Georgia peach crop was unusually free from injury by the plum curculio during the 1933 season. There was a light carry-over from the previous season. The emergence of adult first-generation curculios, which produce the second brood of larvae in the fruit at harvest time, was delayed several weeks by dry weather during the period when the insect was in the ground. The crop thus escaped serious injury.

Although the residues of arsenic on peaches have rarely been found in excess of the tolerance of 0.01 grain of arsenic trioxide per pound, there appeared some danger that the lead residues in areas in which applications are necessary for second-brood curculio might in some cases be greater than the tolerance as first announced of 0.014 grain of metallic lead per pound. The Bureau, therefore, issued to State and experiment station entomologists a revision of its spraying recommendation for southern peach orchards, changing the last lead-arsenate application from 4 weeks to 6 weeks before harvest, and emphasizing the importance of supplementary control measures, such as jarring, cultivation, and the destruction of infested dropped fruit. The analyses of peaches sprayed in accordance with various schedules in 1933 indicate that the regular schedule followed in areas in which two broods occur, which calls for an application of lead arsenate 4 weeks before harvest time, carries the residue of lead approximately to the 0.014 grain per pound tolerance indicated for the next growing season; in exceptional cases the residue was somewhat in excess of this figure. It is believed that by a slight modification of the spray program, the avoidance of excessively heavy spraying, and a greater emphasis on the supplementary measures just mentioned, the residue problem on southern peaches may be handled without serious difficulty. The spray

schedule recommended for northern peach orchards appears to be unobjectionable from a residue standpoint.

Experiments to determine the effectiveness of schedules in which the dates of the final application of lead arsenate were varied from 4 to 7 weeks before harvest were conducted at Fort Valley. Because of the lightness of the infestation, the results were inconclusive, and further experiments are needed in order to determine both the relative effectiveness of various schedules and the quantity of lead residue resulting from them under a range of climatic conditions.

Because of the position taken by the Department in early spring regarding residues of fluorine, the experimental work with fluorine compounds for the control of the plum curculio was somewhat curtailed, although a number of plots were included in the experiments at Harriman, Tenn. The results of these experiments on curculio control have not yet been reported. The residue analyses suggest that either cryolite or barium fluosilicate may be substituted for lead arsenate in all regular applications without causing residues of fluorine in excess of the 1933 tolerance.

ORIENTAL FRUIT MOTH

The work with parasites of the oriental fruit moth has been continued along the lines discussed in earlier reports. During the season of 1932 the collecting and rearing of *Macrocentrus ancylicivorus* Rohwer was continued on a slightly reduced scale, in cooperation with a number of State and local organizations. A total of nearly 40,000 adults of this species were reared, and these were liberated in 132 colonies in 15 different States. This species has now been introduced into the most important peach-growing districts in which the fruit moth is a factor. Although there are a number of localities in which liberations are yet desirable, the work with *Macrocentrus* has for the most part been suspended, as a part of the necessary economy program.

Mention was made in last year's report of the transfer of the search for foreign fruit-moth parasites to Japan, where the parasite species were found to be rather numerous and effective. During the latter part of the season of 1932 several sendings were made, and shipments have continued in increasing volume during the season of 1933. Unless known to be entirely primary in habit, each parasite species is received and handled under close observation until experience with it has demonstrated that it can safely be released in orchards. Among the species received and liberated thus far may be mentioned the following: *Cremastus flavoorbitalis* Cam., *Orgilus*, n. sp., *Bassus* sp., *Apanteles* sp., *Elodia flavipalpis* Ald., *Diocetes molestae* Uch., *Phanerotoma grapholithae* Mues., *Macrocentrus thoracicus* Nees, and *Pristomerus vulnerator* Panz.

In addition, several fruit-moth parasites were obtained during 1932 in Australia by an investigator who was sent there primarily for the purpose of obtaining parasites which might be useful in the control of the Japanese and Asiatic beetles. One of these proved to be in part secondary in its habits and was not liberated, but two of them, namely, *Gambrus stokesii* Cwfd. and *Perisierola angulata* Mues., have been released.

Investigations of bait traps for the control of the oriental fruit moth have been continued at Cornelia, Ga. In spite of the lightness of the infestation during the season of 1933, significant information has been obtained. The outstanding bait during the season has been terpenyl acetate, $\frac{1}{2}$ c c per quart in a 10 percent solution of medium-soft brown sugar. This was one of the four baits giving the best results during the 1932 season. Although the large-scale bait-trap experiments have been discontinued, one small, partially isolated orchard was baited during the 1933 season until harvest time. The degree of infestation was determined in this orchard and in two others used primarily for comparisons of various bait materials, as well as in a number of comparable unbaited orchards. The reduction in injury appeared to be 47 percent in one orchard, 77 percent in a second, and 78 percent in a third. This indicates that a considerable degree of control of the fruit moth is possible by baiting comparatively small areas. Because of the extensive inter-orchard movement of the moths the benefits from small-scale baiting are not cumulative from year to year. Continuance of the baits after harvest is considered practical only where large areas are baited. As practiced in one of the orchards baited in 1933, baiting should cost not more than \$3.50 per acre.

A special study has been made of the influence of weather conditions on the behavior of the moths. When temperatures are favorable—above 60° to

65° F.—light intensity appears to be the most important factor regulating moth behavior. The moths seem to be the most active when the light intensity is less than 0.5 foot candle. Complete darkness, however, as well as light intensity of more than 30 foot candles, will practically stop their activity.

Limited field experiments with insecticides for the fruit moth were conducted at Vincennes, Ind., in 1932. The results of these experiments indicate a partial reduction in the fruit-moth infestation from the use of barium fluosilicate, cryolite, nicotine tannate, and nicotine sulphate, each used with 1 percent of a white-oil emulsion. These reductions, however, were not sufficient to constitute commercial control, and severe injury developed in the plats sprayed with the fluorine compounds in combination with the oils.

OTHER PEACH INSECTS

Because of the suspicion that has been directed toward the peach borer as a possible agent in the transmission of the phony peach disease, greater attention is being given to the biology and control of this insect. Detailed life-history studies on which orchard control is based are practically completed and will be summarized for publication in the near future. Further biological work on the feeding habits of the larva and the adult habits of oviposition and flight are indicated in connection with the possible relation between the peach borer and the phony peach disease. Emulsions of cottonseed oil carrying paradichlorobenzene in solution have continued to give good results in the control of the peach borer on trees of all ages, without causing appreciable injury. It is hoped that it may be possible to extend the use of this treatment to peach nursery stock. The chief problem in using the para-oil emulsion has been the regulation of the quantity applied to each tree. The Fort Valley laboratory has developed a very satisfactory device for this purpose.

Further work is being done in the control of the San Jose scale. Certain lubricating oils having viscosities within the usual range, but having a high volatility, have been found less effective in scale control. Lime-sulphur in the last 2 or 3 years has been found to have a rather low degree of efficiency in the control of the San Jose scale in southern peach orchards, and the oils are being given preference in recommendations for that region.

NUT INSECTS

Because of the reduction in appropriations, it has been found necessary to curtail very materially the work undertaken on nut insects. The chestnut-weevil investigations are being practically discontinued, although a limited number of observations will be made by the personnel of the Takoma Park, Md., laboratory. Pending a determination as to the future of the work under this allotment, the activities at the Shreveport, La., station, dealing chiefly with the pecan phylloxera and the obscure scale, have been suspended for the time being.

THE PECAN NUT CASE BEARER

The results previously reported in the control of the pecan nut case bearer by the use of nicotine sulphate have been fully corroborated by further experiments conducted during the early part of the season of 1933. The percentage control resulting from the use of nicotine sulphate (40-percent nicotine) 1:1,000 in various combinations was as follows: With bordeaux mixture 3:4:50, 19 percent; with 3 different white-oil emulsions, each at a strength of three fourths of 1 percent, 91, 92, and 94 percent, respectively; with fish oil one fourth of 1 percent, 90 percent. The white-oil emulsions were much less effective when used alone. These treatments are somewhat expensive, but with an improvement in economic conditions they may well prove practical for growers who are suffering severe losses from the nut case bearer.

At the Brownwood, Tex., laboratory 3 field experiments in the season of 1933 with lead arsenate, 3 pounds to 50 gallons, gave reductions in nut-case-bearer infestation of 82, 96, and 96 percent, respectively. These applications, made under the semiarid conditions of central Texas, caused no foliage injury. The good results obtained are in contrast to the failure of lead arsenate to give satisfactory control under conditions that exist in southern Georgia. Further confirmation of these results, both as to control and foliage injury, is needed before recommendations can be made to the pecan growers of Texas.

Experiments have been conducted with the egg parasite *Trichogramma minutum* for the control of the nut case bearer as well as of certain other pecan insects. With marked improvements in the rearing technic, it has been possible to increase enormously the number of parasites reared and to reduce the cost per unit. Liberations of large numbers of the *Trichogramma* at the proper time in several pecan orchards infested by the pecan nut case bearer, however, have not resulted in any apparent reduction in the infestation. It has been found that several strains of *Trichogramma* exist, which vary greatly in their behavior. Most of the work with pecan insects has been done with certain of the darker strains. It seems desirable in further experiments to determine the possibility of utilizing one or more of the yellow varieties.

BLACK PECAN APHID

The black pecan aphid (*Melanocallis caryaefoliae* Davis) appears to be of increasing importance in the southeastern pecan-producing areas. It seems to be especially abundant in orchards which have been sprayed with bordeaux mixture. For instance, recent counts showed the infestation on bordeaux-sprayed trees to be 10 times as great as that existing on similar trees not sprayed with bordeaux. The reason for this difference has not yet been determined.

This aphid causes a premature defoliation, which, if extensive, has a serious effect on the crop of the following season. Records taken in the spring of 1933 showed that on trees in which the aphids had been controlled by spraying, 23 percent of the shoots produced blossoms, as compared with less than 2 percent in unsprayed trees which had been defoliated by the aphid.

Extensive experiments have shown that, when combined with standard-strength bordeaux mixture, nicotine sulphate (40-percent nicotine) as dilute as 1 part in 4,000 will give practically complete control of the pest. Kills ranging from 96.6 to 99 percent have resulted from the use of nicotine sulphate 1:4,000 with white-oil emulsions at strengths of one half of 1 percent to 1½ percent. Different soaps varied in their value for use with nicotine sulphate and were on the whole less satisfactory than bordeaux mixture.

OTHER PECAN INSECTS

Under conditions of very light infestation, last season's results in the control of the pecan phylloxera (*Phylloxera devastatrix* Pergande) have been duplicated. Good control has been obtained with nicotine sulphate, applied either in the late-dormant or delayed-dormant period. The best results were obtained with nicotine sulphate (40-percent nicotine) 1:800 with lime-sulphur at various strengths. Nicotine sulphate with soap, and with oil emulsions from 1 to 4 percent in strength, was nearly as effective.

The investigations of the obscure scale have been practically completed, and reports on the studies are being prepared for publication. The susceptibility of the pecan tree to injury by oil sprays limits the strength of oil that can be used. Fortunately, however, the obscure scale has only one generation a year and multiplies much less rapidly than many other species of scale insects, such as the San Jose scale. Four percent of oil in the form of lubricating-oil emulsion appears to be reasonably safe, and an application at this strength will satisfactorily hold a scale infestation in check, although complete kill cannot be obtained. If the trees are in a vigorous, active growing condition, strengths of oil as high as 6 percent may be used with a fair degree of safety and a considerably more complete kill of the scale. Considerable injury has been caused to recently topworked pecan trees the last few years by the insect known as the American plum borer (*Euzophera semifuneralis* Walk.). The larvae tunnel around the sprouts near the point of junction with the tree, weakening the sprouts and causing them to be readily blown off by the wind. Experiments conducted at the Brownwood, Tex., laboratory in March 1933 showed that this insect may be fairly well controlled by painting the injured areas with a mixture of 1 pound of paradichlorobenzene in 2 quarts of cottonseed oil, as used for the lesser peach borer. No injury resulted from the treatment.

The representatives of the Bureau of Entomology at Albany, Ga., are cooperating with those of the Bureaus of Agricultural Engineering and Plant Industry in studies of spraying and dusting machinery and accessories for use in applying insecticides and fungicides to pecan trees.

Experiments are under way with the control of the pecan weevil by the use of carbon disulphide emulsion and other soil fumigants against the larvae or pupae in the soil. If effective treatments of this nature can be worked out, they would be useful chiefly in dealing with portions of orchards most heavily infested. This species is often concentrated chiefly in a limited number of trees in a given orchard. Three years of work have shown that the hydrated-lime spray, although partially effective as a repellent against the adult weevil, is not a practical control method against severe infestations.

GRAPE INSECTS

The already serious spray-residue problem on grapes was greatly intensified by the action relating to residues of lead. In order to give to the entomologists of the experiment stations of the various States full information on the subject, a statement was sent to them in the late winter. In addition to outlining the situation, recommendation was made that in the post-blossom application for the grape-berry moth the lead arsenate formerly recommended be replaced by calcium arsenate, which in grape-spraying experiments over a period of more than 10 years in the Lake Erie grape belt has given results practically equal to those obtained with lead arsenate, and with comparatively little spray injury, except on certain varieties such as Ives, which constitute a minor part of the total acreage. Although this will not overcome difficulty with arsenic, it will eliminate the lead portion of the residue. In place of second-brood applications of arsenicals, emphasis is being placed on the cultural control methods which have been discussed in earlier reports.

Experimental spraying has been continued with various possible substitutes for arsenicals. The only material showing promise has been nicotine tannate with certain spreaders. Further studies of the effect of cultural-control measures have given very encouraging results. Even though heavy and frequent rains during early May of 1933 and the baking of the soil by excessive heat and dry weather during June interfered seriously with the cultural-control operations, the reductions in berry-moth infestation have been very encouraging.

BLUEBERRY MAGGOT

As indicated in last year's report, the calcium-arsenate dusting method worked out by the Bureau has proved to be a commercially practical and satisfactory treatment for the control of the blueberry maggot. Owing to the practical completion of the investigational work on this project and to the necessity for curtailment in expenditures, work on this insect was discontinued and the laboratory at Cherryfield, Maine, closed at the end of the calendar year 1932.

SUBTROPICAL FRUIT INSECTS

CITRUS RUST MITE

The Orlando, Fla., laboratory has continued to give special attention to the problem of the citrus rust mite and its control. A comparison of russeted fruit with bright fruit not attacked by rust mites has shown that the injured fruit loses weight and shrivels more rapidly than the uninjured. Contrary to popular belief, the russeted fruit contained a higher percentage of acid than the uninjured fruit. It has been found that iron sulphate adds very greatly to the effectiveness of lime-sulphur in the control of this species. The Orlando laboratory is also cooperating with other bureaus of the Department in a detailed study of the effects of lead arsenate and other insecticides on the maturity of citrus fruits.

CALIFORNIA RED SCALE

At Whittier, Calif., the investigation has been continued of the resistance of the red scale (*Chrysomphalus aurantii* Mask.) to fumigation with hydrocyanic acid gas. As basis for the proper timing of controls, an intensive study has been made of the seasonal behavior of the red scale in respect to numbers, vitality, and the proportion, in different seasons of the year, of the stages now known to be most resistant to cyanide fumigation. This study has also covered the behavior of the scale in both coastal and foothill locations and as influenced by picking methods and other orchard operations. The important control

features of the year have been the further demonstration of the efficiency of the combined treatment of oil spray followed by fumigation and the determination of a means of lessening the cost of such treatment. By the development of a "skeleton spray" it has been found possible to reduce the cost of the double treatment by a saving of 30 percent in spray material and upwards of 20 percent in labor and apparently with no loss in efficiency, and with less risk of injury to the tree and fruit. A large part of the weakness of fumigation has concerned the scale on the exterior of the tree. The skeleton spray is aimed at this weakness and consists of a thorough application to the outside foliage of the trees with no effort to penetrate to the interior portions, to be later followed by fumigation. In cooperation with the Bureau of Chemistry and Soils numerous gases have been tested alone and in combination with hydrocyanic acid gas but so far nothing has been found equaling cyanide in toxicity to the scale or indicating an equal margin of safety to the foliage.

CITRUS THRIPS

The citrus thrips in California is primarily a pest of the interior rather than the coastal districts. The work of the year with this pest, hitherto conducted in the San Joaquin Valley, has been centered in southern California. The remedy for the thrips is in dusting with finely divided sulphur and the beneficial results increase in proportion to the fineness of the sulphur. By arrangement with owners, demonstration work in the southern California area is being conducted in six orchards, the full results of which will not be available until the time of harvest. Preliminary surveys have indicated little thrips damage in the orchards given the standard treatment of three dustings. Work has included variation in the number of dustings and, for comparison, spraying with the lime-sulphur wash, the advantage distinctly remaining with the three applications of sulphur dust. Closely related to thrips injury is that due to winds, comparative study of which, conducted in Ventura County, indicates that scarring by winds may be fully as great as that by thrips. The early studies in the Lindsay district indicated that the sulphur dusting gave also satisfactory control for light infestations of the citricola scale. Extensive experiments have, therefore, been carried out in southern California to determine the value of sulphur dust against both the gray and the black scales, results of which must wait winter harvest for determination.

DATE-PALM INSECTS

Further experiments have been conducted with various heat treatments for the control of the red date scale. When the treatment was conducted in dry air, the offshoots lost as much as 20 percent in weight, but seemed to suffer no permanent ill effects. The most practical method of treating the offshoots seems to be to place them in a room maintained at a temperature of 120° F. for a period of 65 hours.

The date mite (*Paratetranychus heteronychus* Ewing) has been found to be readily controllable by the use of sulphur dusts; in the same series of experiments, nicotine dust was found to be ineffective. Information is being obtained as to whether certain desert shrubs and grasses are serving as reservoirs of infestation by these mites, permitting reinfestation of the date palms.

INSECTS AFFECTING MISCELLANEOUS ORNAMENTALS

The attention of the New Orleans station has been devoted chiefly to fundamental studies of oil sprays for the control of the camphor scale and certain other species of scale insects and mealybugs. Experiments with 3 oils having unsulphonatable residues of 67, 84, and 94 percent, respectively, but having other characteristics nearly identical, demonstrated that there was no difference in the insecticidal efficiency of oils having unsulphonatable residues within this range. The field applications to camphor trees of the oil having 67 percent unsulphonatable residue, diluted to contain 2 percent of oil, caused a heavy leaf drop; the other 2 more highly refined oils caused very few leaves to fall. Tests of 3 oils differing only in their viscosities, which were 83.5, 146, and 220 seconds, respectively, showed that their effectiveness increases with each increase in viscosity within these limits. Determinations of the quantity of oil deposited per unit of area were made, following a method developed at the New Orleans laboratory by the Bureau of Chemistry and Soils, which is cooperating with this Bureau in these investigations. The oils having higher

viscosities deposited greater quantities of oil per unit area, which in large measure appears to be responsible for the increased scale mortality.

The biology of a mealybug attacking fig, previously identified as *Pseudococcus citri* Risso, but apparently different in certain respects from the greenhouse form which goes under the same name, has been studied, along with the work with oil and other insecticides for its control. Unfortunately, the oil sprays have been found too injurious to fig foliage to justify their use for the control of the fig mealybug. Investigations of other insecticides now include numerous other contact materials such as pyrethrum, rotenone, nicotine, and certain thiocyanates. For the most part these are dissolved in oil which is then emulsified and diluted below the point of danger of oil injury to the plant, which is below the concentration of oil that is effective alone against the mealybug. Results from this work are not yet available.

SHADE-TREE AND HARDY-SHRUB INSECTS

The work on this project has been carried on, as usual, under the direction of William Middleton and is largely service in character, due to the limited funds available for the work and the wide demand for information. The correspondence has continued especially heavy, the total for the year from the Washington Office being 2,355 letters. Advice on the identity, the prevention of the injury, and the control of insects has been furnished to private owners of trees, to officials, and to tree workers.

Some inspections of tree and shrub conditions were made during the year, including Arlington National Cemetery, the Pan American Union, and the Soldiers' Home in Washington, D.C., and properties of the Williamsburg Holding Corporation of the Rockefeller Foundation, Williamsburg, Va.

The accumulation by observations of data tending to aid in the control of injurious species has continued and some little research has been carried on. This is especially true at the Palo Alto Laboratory in California. The biological and control studies of the cypress bark beetle being carried on at the Palo Alto Laboratory have been continued and distinct progress is being shown in these investigations, although it is yet too early to predict conclusions.

Cooperation with the Gipsy Moth Laboratory of the Division of Forest Insects has been carried on through the liberation of elm-leaf-beetle parasites and by the collection of eggs, both for rearing the parasites at the laboratory and for studies of the survival or recapture of the parasite after liberation.

FRUIT FLIES

Studies of various fruit flies have been continued at the laboratories in Hawaii, Mexico, and the Canal Zone. In addition a special study was begun in November 1932 at Key West, Fla., of the West Indian fruit fly.

HAWAII

At the Honolulu Laboratory much additional information has been obtained on the life history and habits of the Mediterranean fruit fly and the means of its control. Special attention has been given to the study of attractants. All grain baits have been found to be attractive to both sexes of flies but the mixture based on rice middlings, in this respect, has excelled all the others. In the determination of the relative toxicity of various poisons, approximately 25,000 adult flies of known age and parentage have been used in laboratory tests. The four poisons which have proven most effective are copper sulphate, tartar emetic, lead arsenate, and sodium arsenite. The addition to such poisons of certain materials such as fruit juices and especially a combination of ammonia and geraniol has stimulated feeding and thus increased effectiveness. Practical tests of these poisons in mango orchards, now covering a period of 18 months, indicate that even under Hawaiian conditions of general infestation considerable protection can be secured by repeated applications.

MEXICO

The investigation of the Mexican fruit fly (*Anastrepha ludens* Loew) and related species has been continued in Mexico in cooperation with the Mexican authorities. In addition to studies of the habits and host relations of these fruit flies, important additional information has been obtained on the sterilization of various fruits, particularly by the use of vapor heat. Special attention

has been given also to attractants and traps for the collection and destruction of adult flies. The type of glass trap commonly used for house flies in Japan has been found to be very much more effective than other traps for fruit flies in orchards and this trap has recently been adopted for use in the lower Rio Grande Valley by the Bureau of Plant Quarantine. Other work at this station has included further studies on insecticides, and a hitherto unused copper compound has indicated special effectiveness. Practical tests to determine how the material is affected by climatic conditions in the lower Rio Grande Valley are now under way in cooperation with the Bureau of Plant Quarantine.

CANAL ZONE

The work on fruit flies in the Canal Zone concerns four species of *Anastrepha* and also the papaya fruit fly—all New World insects. A continuation of the study of fruit-fly baits has confirmed the superior merit of the tartar emetic bait first indicated in the work of this station the previous year, and this conclusion has been confirmed during the year at the other fruit-fly stations.

Many special subtropical-insect problems have been given attention by the leader of this station, and in two instances he has rendered very valuable service to important fruit-producing interests outside of the Canal Zone. Following a request of the President of Panama, approved by the Department of State, he was authorized to make a special study in the San Blas district of Panama of the serious disease of coconut palms known as "red ring" caused by a microscopic worm (nema). This disease is conveyed from tree to tree chiefly by the palm weevil. A detailed report covering all phases of the problem and presenting practical control recommendations has been submitted to the President of Panama and to this Department. Similarly, at the request of the American Minister in Haiti, endorsed by the Department of State, Mr. Zetek made an inspection, in June 1933, of the "Panama disease" in bananas and plantains in Haiti, the outcome of which was the indication that by careful selection of suckers for planting, this disease, now largely confined to a single plantation, could be eliminated.

It is worthy of note that the parasite of the blackfly imported from Malaya into Cuba and widely distributed in the West Indies and Central America appears completely to have controlled the blackfly in the Canal Zone and Cuba.

KEY WEST

The discovery some 2 years ago of the occurrence at Key West, Fla., of the West Indian fruit fly (formerly known as *Anastrepha fraterculus* Wied. but now determined as *A. acidusa* Walker) led to a preliminary effort on the part of the State to eradicate this pest. As this effort was not entirely successful the State Plant Board of Florida appealed to this Bureau for aid in obtaining exact information as to the biology and host plants of this fruit fly to serve as basis for a more intensive clean-up effort. This study was undertaken in November 1932 and developed much useful information relative to the winter habits and also the relations of this and a related species likewise found to occur there. These studies are being made the basis of a much more intensive and, it is expected, final and successful effort to complete the eradication of this pest in Key West, the only portion of Florida in which it is known to have become established.

JAPANESE AND ASIATIC BEETLES

The work in this field has continued under the direction of C. H. Hadley.

JAPANESE BEETLE

A feature of interest of the year has been the striking reduction in Japanese beetle population in 1933 compared with that of 1932. This was particularly noticeable in the formerly heavily infested sections of Pennsylvania, where in the spring of 1932 the soil population averaged as high as 30 larvae to the square foot, and in the spring of 1933 showed a population generally of less than 7 larvae per square foot. Severe drought in July 1932, during the period when eggs were hatching, appears to have been the important factor causing this reduction. Information secured from soil surveys suggests, however, that

parasitic microorganisms and other natural agencies contributed. On the other hand, during the summer of 1933 weather conditions have been favorable for the egg and early larval stages of the insect. In marked contrast to the reduction in population in the older infested area is an extensive area in southwestern New Jersey where severe injury occurred during 1933. The area of continuous infestation as to all States at the end of the season of 1933 increased from a total of approximately 7,600 square miles at the end of the season of 1932 to approximately 8,600 square miles in 1933. This area includes most of New Jersey, the four or five counties in Pennsylvania surrounding Philadelphia, and approximately the upper half of New Castle County, Del. The density of infestation has also increased in the somewhat separated areas through New York, Connecticut, Rhode Island, Massachusetts, Maryland, Virginia, and the District of Columbia.

During the season, in several instances new growth of certain evergreens (azaleas, rhododendron, juniper, cryptomeria, and arborvitae) was severely attacked by the beetles, where roses and other common food plants near these evergreens had been heavily sprayed for protection, and there was an unusual amount of feeding on clover, alfalfa, bush beans, broccoli, strawberry, lotus, and Japanese barberry.

The effectiveness of the standard Japanese beetle trap has been still further improved and its usefulness, particularly for the protection of the second crop of red raspberries and blueberries, has been further demonstrated.

As a repellent on foliage, the use of lime, in combination with fish oil or linseed oil as a sticking agent, offers promise. Foliage sprayed with rotenone, dihydrorotenone, or derris likewise appears to be more immune to beetle feeding. As contact poisons for the beetle, a number of materials have been tested, with indications that the sodium soaps are more toxic than the potassium soaps, and that the toxicity of rotenone, derris, and nicotine as contacts is increased by the addition of soaps.

As to grub control, it has been found that the efficiency of the lead-arsenate treatment for lawns, etc., may be affected materially by the type of fertilizer used upon treated areas; also, that heavy applications of lime tend to convert the lead arsenate into an insoluble form, making the treatment of little value for the destruction of grubs.

Further tests to determine the reaction of plants to soil treated with lead arsenate, now extending over a period of 1 or more years, indicate that out of 86 perennials 43 were apparently resistant to the insecticide, 19 were retarded in development, and 24 killed. These results, which will be made available to the public, indicate the necessity of making preliminary determination with respect to any type of plant prior to adoption of such treatment.

During the year a number of shipments of parasites, including 13 species, have been made from Japan. Of the imported parasites already established, the situation with respect to *Tiphia popilliavora* Rohwer is very encouraging; this species is very abundant, giving evidence of rapid multiplication, and has continued to spread from points of liberation. Recently established colonies of the introduced *T. vernalis* Rohwer have, in certain instances, developed sufficiently to permit collection from these colonies of enough specimens to distribute colonies in 65 new locations. Field studies on this wasp indicate a very rapid increase and spread in the rolling, hilly areas of eastern Pennsylvania; the flat, sandy areas of New Jersey, however, do not appear to be so favorable for this parasite. In areas where the parasite colonies have become well established, during the summer of 1933 parasitization of Japanese beetle larvae ranging from 7 to 14 percent was observed. Scouting to determine the spread of the fly *Centeter cinerea* Aldrich showed that the areas where the parasite is known to occur had increased about 40 square miles, bringing the total area to approximately 219 square miles. The parasite *Dexia ventralis* Aldrich seems to be holding its own, although no noticeable spread has been observed.

THE ASIATIC BEETLES

The status of the oriental beetle (*Anomala orientalis* Waterhouse) is approximately the same as in the preceding year. The spread of this species has been quite limited, being most noticeable near the old infestation at Jericho on Long Island (N.Y.) and at White Plains, Pelham, and Mount Vernon, in Westchester County, N.Y. Some injury from grubs of this species to strawberries and raspberries has been observed. Injury to turf has for the most part been largely prevented by the application of the lead-arsenate treatment.

The Asiatic garden beetle (*Autoserica castanea* Arrow) continued to spread and in 1933 was found (by scouts of the Bureau of Plant Quarantine) at Aiken, S.C. The finding of this insect at Atlantic City, N.J., also represents a new record. During 1933 this species occurred in greatly increased abundance throughout northern New Jersey, western Long Island, and in Westchester County, N.Y. Extensive plant injury occurred in vegetable gardens in Nassau County (Long Island), especially to peas, cabbages, beets, kohlrabi, swiss chard, parsnips, turnips, spinach, beans, eggplants, and peppers. In early summer the grubs destroyed many plants and later in the season the adults almost completely destroyed plants surviving the grub attack.

The beetles are night fliers and are active when temperatures are above 70° F. Tests to determine the value of light traps showed that the use of an ultraviolet light in a trap resulted in the capture of from 4 to 10 times as many beetles per watt of electricity consumed as when a daylight bulb was used.

CEREAL AND FORAGE INSECTS

The work on insects affecting cereal and forage crops is under the direction of W. H. Larrimer.

GRASSHOPPERS

The grasshopper survey in the fall of 1932 in the northern Great Plains and Rocky Mountain States to determine the location and abundance of eggs showed that, although reductions in infestation had occurred in Nebraska, Colorado, Wyoming, and Idaho, conditions in North Dakota, South Dakota, and northeastern Montana were extremely serious. The resulting infestation in 1933 fully justified the apprehension thus aroused, as severe grasshopper damage developed over practically the whole of North Dakota, central and eastern South Dakota, northeastern Nebraska, and westward over eastern Montana. Although operating under the handicap of considerably curtailed funds, the Bureau detailed not only its regular research men to aid in this emergency but furnished the services of a special expert who devoted his entire time for 3 months to organizing the control work in North Dakota. Through these means it was possible successfully to arouse such counties as possessed sufficient funds for the application of poisoned baits, and this resulted in saving the crops throughout many communities.

In addition to the two-striped, the differential, and the clear-winged grasshoppers, which had caused most of the trouble in recent years in these States, there appeared in 1933 a serious outbreak of the lesser migratory grasshopper (*Melanoplus mexicanus* Sauss.), which has many of the characteristics of the pestilential "Rocky Mountain locust" that devastated the Mississippi River Basin in the seventies and eighties of the last century. Owing to its migratory habits, the advent of this grasshopper over large areas in both the Dakotas and Montana presents the possibility not only of the continuation, but of the extension in the spring of 1934 of the present outbreak.

For the past 3 or 4 seasons the research on grasshoppers has been seriously interfered with by the necessity of doing extension work on methods of control, and in aiding the organization for such work. Progress has, however, been made on methods to determine prospective grasshopper populations—such information to be used as a basis for estimating the need for control and the probable cost. Continued improvement in the baits has been made, particularly along the line of attractants, substitutes for arsenic as a poisoning ingredient, and methods of improving the physical composition of the bait so that it may be attractive to the grasshoppers over a longer period. It has been determined that cane molasses is about as attractive as any other sweet used in bait. When beet molasses is substituted for cane molasses, the addition of amyl acetate is desirable. Excellent results can be obtained during hot, dry weather by use of a bait made up with the simple ingredients of wheat bran, arsenic, and water. The fluosilicates of sodium and barium have given considerable promise as substitutes for arsenic in the bait. More rapid killing of grasshoppers has been accomplished when these materials have been substituted for arsenic but lack of uniformity in results prevents the change in the standard recommendation of arsenic for use in grasshopper baits. In an attempt to produce a bait attractive to grasshoppers over a longer period, various oils have been substituted for water. After trial of many types of vegetable oils, a low-grade, cheap lubricating oil of a viscosity of 40 seconds Saybolt proved to be as good as any. The bait in which such oil was substi-

tuted for water has remained attractive over a much longer period and produced a more sustained killing effect than baits prepared with the usual formula including water. These tests should be continued and the improved baits given further extensive trials in the field before any change in the standard poisoned-bran bait formula is recommended.

Continued observations have verified the advantages, instead of "stubbling in", of plowing stubble as a cultural control for grasshoppers, in that it not only serves to destroy the eggs of these pests but also furnishes a much more desirable seed bed. An emergency circular, designed to furnish timely information on this phase of grasshopper control, was issued in September 1933 for use in the outbreak area.

Small grain crops, sown as early as possible, usually reach maturity ahead of serious grasshopper damage. Further studies have been made on the time of hatching of the eggs of various species of grasshoppers, as such information may have a bearing on the time, as well as the number, of applications of bait on the hatching grounds.

Continued observations on the migratory phases of various species of grasshoppers have been made during the present outbreak, and these studies may later have a practical bearing especially on the species *Melanoplus mexicanus* Sauss., should the latter prove to be a phase of the destructive Rocky Mountain locust of the early Plains days.

MORMON CRICKET

In the elevated plateaus of the Rocky Mountain region a large, black, wingless, long-horned grasshopper popularly known as the "Mormon cricket" breeds periodically in great numbers. In May 1932 an outbreak of this species appeared rather suddenly on the Fort Hall Indian Reservation in eastern Idaho. The suddenness of the outbreak and the lack of familiarity with the species and adequate control measures caused considerable consternation to the officials of the reservation as well as residents of neighboring counties. Upon the advice of Federal and State entomologists, emergency control measures by trenching were largely replaced by the recommended combination of barriers and dusting, and much of the hysteria subsided. The infestation, however, was of such magnitude as to present a real threat to the neighboring cultivated crops and, but for the unusually vigorous control campaign that was conducted, considerable loss would have resulted. While practically all crops were protected, it was impossible to prevent egg laying in the foothills bordering the cultivated areas. As a result, in the spring of 1933 the outbreak was repeated; but through a pooling of the resources of the Indian Service, assisted by the purchase by this Bureau of calcium arsenite dust and dust guns, the control campaign was continued with little or no loss of crops.

There also developed, during the season of 1933, outbreaks of this species in 5 or 6 other isolated places in Idaho, also on the Crow Indian Reservation in south-central Montana; and an old infestation, in the Blue Mountain area in northwestern Colorado, spread eastward toward the cultivated areas in that section. The outlook for next year, therefore, is for considerable trouble from this insect in the areas mentioned.

EUROPEAN CORN BORER

Owing to unusual and unfavorable spring and summer conditions for corn culture in the Great Lakes region of European-corn-borer infestation, the increase in damage by this pest forecast in our report of last year did not develop. Although the rate of infestation and winter survival of the pest was found to be quite as high as in former years, corn was planted throughout this area much later than usual and developed but slowly in the early part of the season. The result was that when the corn borer moths emerged to lay their eggs the corn was too small to be attractive. In addition to this handicap, weather conditions during the egg-laying period continued unusually dry and hot, thus destroying many of the egg masses shortly after deposition. At present, indications point to very little if any general increase in infestation and spread in the one-generation area. In the two-generation area a very perceptible increase in infestation occurred during the season of 1933. Individual sweet-corn fields, under conditions leading to exceptional concentration of the borers, in Massachusetts, Rhode Island, and Connecticut were a complete loss as to marketable ears of sweet corn.

The introduction and colonization of parasites of this pest have proceeded rapidly and satisfactorily during the year. In addition to 666,000 parasites of various species, some 3,400,000 parasitized larvae of the pest were received from Europe. Especial attention is being concentrated on the redistribution of corn-borer parasites in this country, particularly in the eastern edges of the Corn Belt wherever infestation of the pest is sufficiently intense to permit the parasites to obtain a firm foothold. By these methods it is hoped that the parasites may be established as promptly as possible after any given area becomes infested.

A consolidation of the three field laboratories formerly located at Sandusky and Toledo, Ohio, and at Monroe, Mich., became effective July 1 last. General headquarters are now established at 1920 Parkwood Avenue, Toledo, Ohio.

Nine publications treating on various technical phases of the corn-borer investigation were issued by the staff during the year.

HESSIAN FLY

The threatened outbreak of the hessian fly, commented upon in our report of last year, was largely dissipated by drought and high temperatures that obtained in the past summer so that the conditions of infestation prevailing this fall, in most of the wheat-growing areas east of the Rocky Mountains, are much less threatening. Comparatively small areas in several of the States such as Kansas, Missouri, Illinois, and Indiana are still quite heavily infested, but it is believed that the danger of a great general outbreak is over for the present, although the same meteorological conditions which vanquished the threatened general invasion have drastically reduced wheat yields in many localities.

For some years an investigation of the hessian fly as a pest of wheat in the Pacific Northwest has been under way. This work has progressed sufficiently to enable the Bureau to issue a report of it in a technical bulletin issued in May of the present year.

SUGARCANE INSECTS

The commercialization of a cosmopolitan egg parasite, accompanied by extravagant claims as to its efficiency in the control of the sugarcane borer, has led to much controversy for some years past among sugarcane growers and others in the Gulf States as well as other sugarcane-producing countries of the world. In order to decide the question of its utility in this relation in a fair and unbiased manner, the Bureau recently has undertaken in Louisiana a comprehensive investigation of the matter and is engaged in the colonization of this parasite (*Trichogramma minutum*) under conditions which it is felt will eventually furnish the growers with reliable information on the subject. During July approximately one half million individuals of this parasite were released for colonization in experimental sugarcane fields under controlled conditions which will permit comparison of results with those in fields not so treated.

The sugarcane borer is the chief limiting insect factor in the production of sugar in the Gulf States and hence much attention has been focused on the importance of control of this pest. Recently it has been observed that some important varieties of cane were much less frequently attacked by the borer than were others. It is believed that this may be due to the variation in the hardness of the rind of the cane, and an investigation of this question is being made. Preliminary results seem to indicate that such variation may be an important factor in the degree of injury inflicted by this pest to sugarcane.

The work of introducing the insect parasites of the sugarcane borer from South America has been recently concluded and a full report of this work was published as a technical bulletin during the year.

PEA APHID ON ALFALFA

The investigation of the pea aphid as an enemy of alfalfa in the Antelope Valley of California has progressed sufficiently to permit the publication of the results and definite recommendations for the control of this pest. Two circulars are being issued containing such information. Until recently it has been somewhat of a mystery how this aphid survived the intensely hot dry summer months in the valley. It has now been discovered, however, that comparatively small numbers of true females appear in late spring which lay eggs that are resistant to desiccation and that aestivate during the dry period and thus perpetuate the pest.

ALFALFA WEEVIL

There has been no important spread of this pest during the year. The appearance of the insect in the San Joaquin Valley of California which was recorded in our annual report of last year required the initiation of an effort to establish its principal insect parasite in this newly infested district. Action taken in the fall of 1932 resulted in the introduction in the spring of 1933 from Nevada of a small colony of this parasite (*Bathyplectes curculionis* Thoms.) and surveys made recently indicate that this effort was successful. There are now being held in cold storage, pending the arrival of the proper season for release, some 13,000 cocoons of this parasite for further colonization in California.

RANGE CATERPILLAR

The project for the colonization of the controlling parasite (*Anastatus semiflavus* Gahan) of the range caterpillar in northeastern New Mexico has progressed rapidly during the year, in which a total of more than 4½ million eggs have been parasitized at the laboratory at Tempe, Ariz. Of these about 3,500,000 were colonized during the summer of 1933. Unfortunately for this work, however, extreme drought and overgrazing have served greatly to reduce the host insect and have thus interfered seriously with the immediate success of this effort.

CHINCH BUG

A recrudescence of that formidable enemy of growing wheat, other small grains, and corn, the chinch bug, has developed rapidly during the past 12 months. In addition to ravages committed in its usual range through Iowa, Kansas, Missouri, Illinois, and Indiana, it appeared in the cornfields of eastern Pennsylvania in such numbers as to cause general complaint. One unusual development was its appearance in Vermont and in the Catskill Mountains of New York, where it injured lawns and golf greens to some extent. Where the barrier methods of defense for cornfields, developed by Bureau and State entomologists, were utilized in time, these proved effective. The relationship of drought to chinch-bug abundance has elsewhere been noted (p. 2).

Early in September at a meeting of State and Federal entomologists at Hamilton, Ill., the best methods for control of the chinch bug were discussed and a uniform plan to meet the chinch-bug situation in the Corn Belt States was adopted. Briefly, this plan of attack includes (1) the adjustment of crops to better fit into control measures, such as the elimination of barley and millet and the substitution of winter wheat in such rotations, the growing of soybeans, and the planting of chinch-bug-resistant varieties of corn; (2) winter burning of bunch grass, leaves, and other debris along fences, hedgerows, and borders of wood lots, where practicable, to destroy the hibernating quarters of the overwintering bugs; (3) the use of barriers to prevent the migration of young, first-generation bugs from small grain to corn; creosote barriers or barriers of coal tar which contain the maximum of phenols and cresols, as well as naphthalene, are most effective.

WHITE GRUBS

The past year has been characterized by rather widespread and intense injury to pasture lands and field crops by various species of white grubs from the Atlantic seaboard to Iowa. An intense local outbreak in Loudoun County, Va., was investigated by Bureau experts and as a result recommendations for control in that locality were published in a regional agricultural periodical. The condition in the North Central States was deemed serious enough to require the resumption of the general investigation of white grubs formerly carried on there with La Fayette, Ind., as a base. An expert released from another project has been transferred there to resume this project.

LEAF HOPPERS

That the importance of leaf hoppers as pests of forage crops is not sufficiently realized was shown during the year by an experiment conducted with the bean leaf hopper on Alfalfa at the Arlington Experiment Farm. The results of this indicated that where heavy infestation of this insect occurs it may reduce the crop at least 25 percent and also reduce the grade of the resulting hay crop materially.

A bulletin giving general information on the control of leaf hoppers in cereal and forage crops was issued last October.

SOUTHWESTERN CORN BORER

A cultural control satisfactory for adoption in much of the area infested by this insect (*Diatraea grandiosella* Dyar) has been determined during the year. This information and many other facts regarding the significance of this pest to the corn culture of the Southwest are contained in a comprehensive technical bulletin at present in press.

CLOVER-POLLINATING BEES OF THE PACIFIC NORTHWEST

A study of the identity and habits of the bees chiefly concerned in the pollination of red clover in the Pacific Northwest has been in progress for several years as a minor project of this Bureau. The results show that in western Oregon the most effective species is a bumblebee, *Bremus vosnesenskii* Redoszkowski, while in eastern Oregon, especially in Malheur County, the chief pollinators, contrary to popular belief, are the honeybee and leaf-cutter bees.

TRUCK CROP AND GARDEN INSECTS

Investigations of truck crop and garden insects have been continued during the past year under the direction of W. H. White and P. N. Annand.

WIREWORMS

Study of the irrigated land wireworms has been continued in Washington and California, of the sweetpotato wireworm (*Heteroderes laurentii* Guér.) in Alabama and Mississippi, and of the sand wireworm in South Carolina. The long life cycle of most of these pests, their underground habitat, and their surprising tenacity of life, preclude the effective use of remedies applicable to other insects. The means of control of wireworms which seem to have practical value fall into two classes, namely, chemical and cultural. Of the first, soil intermixture with carbon disulphide or with crude naphthalene, when carried out under proper conditions of soil temperature, has given satisfactory results in the irrigated sections of the Northwest. Treatment with carbon disulphide costs about double the treatment with naphthalene but is more effective, giving substantial freedom from this pest for at least 3 years. It is applied by injections of 1 ounce of the liquid to a depth of about 4 inches in the soil at intervals of about 18 inches. The application of crude naphthalene is made by thoroughly mixing it in the upper 10 inches of soil at the rate of 800 pounds per acre. In test plots this treatment has given a kill of 85 to 95 percent of the soil population of wireworms. To obtain the best results with either chemical it is necessary that the soil be in a good state of tillage and its temperature above 70° F.

As to cultural means, a careful study of soil moisture and temperature in their relation to wireworm populations has given the clue to the control of these pests. A high mortality is secured by allowing the soil to become extremely dry or by flooding the land after crop harvest. These methods are particularly applicable to irrigated areas. In the case of flooding, temperature is again an important factor, and this method to be most successful should be practiced during July and August. At temperatures below 60° F. submerged wireworms may survive for long periods. In one experiment of a week's duration where the temperature of the submerged soil reached 75°, from 95 to 100 percent of the wireworms were killed.

As to soil desiccation, laboratory tests have shown that wireworms cannot survive longer than 48 hours where the soil humidity is lower than 90 percent. Field tests where soil of irrigated lands was allowed to dry throughout the surface foot to this percentage, and remained so for several weeks, exhibited a marked reduction in wireworm populations. It is suggested that in carrying out this means a system of rotation be adopted which will give this control every 4 or 5 years.

In the case of the sand wireworm, the work of the past season has indicated successful control by absolutely clean cultivation for 60 days or more during February, March, and April—except as to cotton fields, where the roots appear to remain sufficiently succulent to support these pests over the period. This

wireworm has a 1-year cycle only and therefore there is a period during each year when the soil is relatively free from them. Studies of crop rotation as a means of reducing damage by this wireworm are now under way.

BEAN INSECTS

MEXICAN BEAN BEETLE

The spread of the Mexican bean beetle has been less extensive than during 1932, although one long-distance jump to Minnesota has been reported. The survival of the bean beetle in the Northern States has been progressively higher with increased damage for several years, probably owing to the milder winters which have prevailed.

Field and laboratory tests of comparatively new insecticides have been continued in Ohio and the Norfolk, Va., area and the following results seem to be quite conclusive: Potassium hexafluoroaluminate and synthetic cryolite are satisfactory for the control of the Mexican bean beetle when used as sprays at the rate of 3 pounds to 50 gallons of water. Barium fluosilicate (80 percent) used at the rate of 5 pounds to 50 gallons of water gives satisfactory control. Fluorine compounds have not given satisfactory control when used as dusts. The current recommendations for the use of magnesium arsenate should be adhered to except that where the infestation is heavy the dosage should be increased from 1 to 2 pounds to 50 gallons of water.

In the Estancia Valley of New Mexico practical field experiments have shown that undiluted calcium arsenate is the cheapest material for use against the Mexican bean beetle and that no plant injury results in that district with applications of 4 to 6 pounds per acre.

From the standpoint of poisoning residues on edible portions of the plant, it has been shown that applications of the stomach poisons mentioned, up to the time the pods form on bunch beans, usually give sufficient protection to the crop and avoid the problem of poisonous residues. Should the crop require spraying after the pods have set, pyrethrum or derris extracts must be used.

The tachinid parasite *Paradexodes epilachnae*, introduced from Mexico in 1930, has been reared continuously for approximately 32 generations. During the calendar year 1932, 18,642 flies were liberated in 14 States, making a total of 16 States in which the parasite has been liberated. Remarkable increases during the same season of liberation were found to have taken place in some localities, but to date no authentic records have been obtained of recovery of the parasite a year subsequent to the liberations.

MISCELLANEOUS BEAN INSECTS

Studies of the bean leaf hopper (*Empoasca fabae* Harr.) were carried on in Florida and showed that both Bordeaux mixture and sulphur, the latter used either as a spray or a dust, are effective in reducing infestations.

The work on the lima bean pod borer in California has shown that the first brood develops on wild lupine and the moths then migrate to lima beans, where one brood and a partial second develop. Distance between the wild hosts and cultivated crop has been shown to be important in determining the amount of damage caused by this pod borer. Extensive tests have been made with insecticides in an effort to reduce the losses to the bean grower, not only from injury to the dried bean but also to the green product, and indications have been obtained that worth-while control of this pest can be obtained by the use of undiluted cryolite. No estimate of loss from damage to the green product is available, but in the case of dried beans the loss from injured beans has amounted to about \$1 per 100 pounds. This includes the labor item for removal of injured beans.

BEET LEAF HOPPER

The investigations on the beet leaf hopper have been continued in Utah, Idaho, Colorado, Oregon, and California. Injury by the pest has not been generally severe during the past year except in the Grand Valley in Colorado.

The seventh annual forecast of leaf-hopper abundance, made for the Twin Falls area this year, indicated previous to planting that populations for the season would be low, and the results have confirmed the accuracy of this forecast. Work has been continued at Twin Falls, Idaho, on control of the leaf

hopper by spraying areas of concentration in the desert previous to hibernation in the fall and to migration in the spring. Investigations of the importance of parasites in the control of this pest are also being conducted in an attempt to determine their effectiveness under various conditions and the possibility of utilizing them in control.

No forecast was issued for the Grand Valley in Colorado this year because of uncertainty as to the importance of a large Arizona breeding area of the insect which carried high populations. A large migration of the leaf hoppers apparently occurred from this area in early spring. Its serious nature was recognized immediately and growers were warned to keep their beets in the best of tilth and moisture conditions possible as a means of reducing injury. A continuance of the service in western Colorado will be possible only when more definite information is available as to the importance to the Grand Valley, Colo., district of the breeding areas in Arizona. Eastern Utah breeding areas are important to the Grand Valley in some seasons, but even when low overwintering populations occur here severe injury may result to beets if the Arizona areas are heavily populated.

Further studies in Utah have established rather definitely the fact that the insects responsible for the injury to beets in the central Utah sections originate in the large breeding areas in southern Utah and portions of Arizona and Nevada, and it now appears feasible to forecast conditions for at least a portion of the State.

Direct control operations have been continued in California by spraying the wild host plants chiefly concerned in the fall concentration in the valleys bordering cultivated areas. It is believed that at least 50 percent reduction in beet-field populations has followed such fall spraying. The final tests of the efficiency of this method will come when there is a major increase in populations as a result of climatic conditions favorable to the insect. Destruction of summer hosts, particularly of Russian-thistle, favorably located in the foothills with reference to breeding areas, has been found to be an important factor in reducing populations.

TOBACCO INSECTS

Material reduction of hornworm infestation has been obtained in the Kentucky and Tennessee tobacco districts and in the shade-tobacco districts in Florida by the use of a bait consisting of tartar emetic in combination with amyl salicylate as an attractant to the moths. Such baiting afforded commercial protection from hornworms until the latter part of the harvesting season, when one application of an arsenical was necessary. To secure control on untreated fields an average of 4 to 5 applications of arsenical, together with hand pickings, was required. A series of comparative counts indicated that an approximately 89-percent control resulted from the use of bait.

BERRY INSECTS

Detailed information has been secured on the seasonal history of the raspberry fruit worm, a serious pest in the berry-growing districts of Washington and Oregon. It is found that 51 percent of the larvae and pupae in the soil are within 2 inches of the surface, that 95 percent are within 4 inches, and that cultivation to these depths has killed a good percentage of such larvae and pupae. Extensive tests with sprays have indicated that early applications are most effective in preventing bud damage, but that later applications are necessary for reduction in fruit infestation. A spray which can be used during the latter period without danger of poisonous residues is being sought.

Of a number of mites found causing damage on various varieties of blackberries in western Washington, the red berry mite (*Eriophyes essigi* Hassan) has become a serious pest. It has been found that wettable sulphur, generally used for mite control, may result in injury to blackberry vines under certain conditions. A study of the spread of this pest indicates that scattered infestations occur throughout the area, but that the most general occurrence is in the Puyallup Valley.

Studies of the strawberry root aphid, *Aphis forbesi*, in North Carolina have definitely shown that this aphid is responsible for the death of many of the strawberry plants. However, the dying of plants which has been previously attributed to aphid injury to the root may be caused by other factors, such as

low soil moisture and root rots. Injury is less in new land and is greater in plantings following strawberry, corn, and cotton than in fields which have been allowed to grow up in weeds or grass.

PEPPER WEEVIL

Tests in California on the control of the pepper weevil have shown that calcium arsenate, barium fluosilicate, cryolite, and potassium fluoaluminate are toxic to the weevil, but the fluorine compounds, with the exception of potassium fluoaluminate, even when diluted 50 percent with a neutral carrier, injured the plants, causing some leaf burning and especially dropping of the buds. Damage was much more severe when the foliage was damp or wet than when it remained dry. Calcium arsenate dust still remains the best insecticide for use against the pepper weevil, but it is essential that measures be taken to remove all residues from the fruits.

Further studies of host plants show that the weevil survives during the winter for any length of time only on nightshade and peppers. This emphasizes the value of clean-up, such as plowing up of pepper fields and destruction of nightshade, as soon as the peppers are harvested. Such clean-up has apparently greatly reduced the pepper-weevil population and commercial damage the following year, and it is encouraging to note that the growers are becoming more interested each season in the destruction of such winter hosts.

CELERY INSECTS

The celery leaf tier (*Phlyctaenia rubigalis* Guen.) was not so serious during the past season in Florida as in 1931, but it caused considerable loss in California, where many carloads of celery were seized as a result of excess residues from arsenicals used in attempts to control the tier. These seizures could have been avoided if a pyrethrum dust had been used instead of an arsenical, and according to results obtained on control of this pest in Florida much more satisfactory control would have been obtained. Sufficient information on the seasonal development of this insect has been obtained in Florida to make it possible to inform the growers this year that control would be unnecessary, and thus to save considerable outlay for pyrethrum materials and to prevent their needless application. Fluorine sprays or dusts have not given satisfactory control of the celery leaf tier.

Bait tests for the control of mole crickets have given indications that adults in the spring and early summer are more easily baited than are the nymphs and adults in the later summer and fall. Paris green at the rate of 5 pounds per 100 pounds of mixture is the most satisfactory poison. It has been definitely shown that dry bait is more effective than the wet bait which has been usually recommended.

SWEETPOTATO WEEVIL

Efforts to reduce the infestation of the sweetpotato weevil in Mississippi and Alabama have been continued with satisfactory results. Many farms have been released from State quarantine as weevil-free during the past year in Mississippi. Near Mobile Bay in Alabama a small outbreak of the sweetpotato weevil occurred adjacent to marshes in which were infested morning-glories. Less than 8 acres were included in this infestation. A survey of the adjacent marshes revealed a number of infested patches of morning-glory. The possibility of removal of these morning-glories and the seaside morning-glory in the infested area is under investigation. Cooperation was extended to the State of Georgia in controlling a new infestation which appeared along the coast near Brunswick. Test fumigations of stored seed sweetpotatoes indicate the possibility of eliminating danger of infestation from this source, without seriously affecting the germination of the seed, by fumigation with paradichlorobenzene.

CABBAGE WORMS

A study of the means of control for the various species of cabbage worms is being conducted in North Carolina and South Carolina and in Louisiana, more particularly in relation to the avoidance of harmful residues in the marketed product. These studies indicate that paris green and lime (1:10), lead arsenate and lime (1:5), and calcium arsenate and lime (1:5) can be applied to cabbage under Louisiana conditions, regardless of the number of applica-

tions, up to 20 days before maturity without risk of exceeding the legal tolerance. Applications made during wet periods resulted in slightly smaller residues. The amounts of residue resulting from paris green, lead arsenate, and calcium arsenate applications were about the same at harvest when equal numbers of applications of each were made. Studies on the development of the plant indicate that all leaves likely to receive any of an insecticide applied during the first half of the growth period are shed from the plant before harvest. Arsenical residue exceeds the tolerance limits only when leaves that are on the plant at the time of final application of arsenicals are present in the marketed product.

These tests have shown, however, that neither paris green, nor lead arsenate, nor calcium arsenate will give as effective control of larvae of the diamond-back moth, imported cabbage worms, and cabbage loopers as will derris dusts containing 1.75 percent of rotenone applied at the rate of 12 to 15 pounds per acre, or pyrethrum dusts containing 0.12 percent of pyrethrin I and applied at the same rate. Hellebore was found to give better control than the arsenicals, but was considerably inferior to the derris and pyrethrum products. At present the cost per application of the organic materials, which do not have poisonous residues, is considerably in excess of that of the arsenicals.

GREENHOUSE AND BULB INSECTS

THE BROAD MITE AND THE CYCLAMEN MITE

It has been found that the broad mite (*Tarsonemus latus* Banks) feeds on 49 species of host plants and the cyclamen mite (*T. pallidus* Banks) on 25, of which 16 are attacked by both species.

Sulphur dust was the most effective of nine materials tested against the broad mite, but only low kills were obtained against the cyclamen mite. Repeated fumigation with naphthalene with dosages of from three eighths of an ounce to 1 ounce per 1,000 cubic feet of space controlled the broad mite but was ineffective against the cyclamen mite. Earlier workers reporting successful control of the cyclamen mite by naphthalene were probably working with the broad mite. In further tests with heat treatments a 10-minute immersion in water at 110° F. killed the cyclamen mites on small plants, whereas a 15-minute immersion was required to kill both the cyclamen mite and the broad mite on large plants. On large delphiniums, however, a 25-minute immersion was required to kill the cyclamen mite in the crown below the soil surface. A 30-minute treatment with vapor heat at 110° and 100 percent relative humidity killed the mites as did also the 15-minute hot-water treatment.

GLADIOLUS THRIPS

The gladiolus thrips (*Taeniothrips gladioli* M. and S.) has become widespread and has continued to damage whole crops. This thrips has not been found to overwinter out of doors in the North. In further tests the thrips on stored corms were killed by application of naphthalene flakes or by immersion in Semesan. Small-scale tests showed that control can be obtained by storing corms at controlled temperatures of 36° to 40° F. for 3 months, a practice which will be desirable for use by large growers. In field tests best control on the growing plants was obtained with weekly applications of paris green brown-sugar spray, particularly when spraying operations were started early. The spray injury was not serious and did not reduce the quality of the flowers or of corm production.

Laboratory and greenhouse studies of the gladiolus thrips indicate that the effectiveness of the paris green brown-sugar spray is due to the toxicity and lasting qualities of the deposit it leaves on the foliage. Molasses is a very effective substitute for brown sugar and the combination of it with other insecticides, such as derris extract (rotenone concentration 1-20,000=0.05 percent) and hellebore appeared very promising. The toxic deposit left by the derris extract-molasses spray on gladiolus retains its effectiveness for a much longer period than other derris sprays, even when exposed to direct sunlight. Neither pyrethrum extract nor the nicotine sulphate-molasses spray was efficient though the molasses-nicotine was the most effective of the various nicotine sprays.

BULB INSECTS

Further studies at Sumner, Wash., with the vapor-heat treatment of narcissus bulbs indicated that complete mortality of the larvae of the larger bulb fly (*Merodon equestris* Fab.) was obtained with a treatment of $1\frac{1}{4}$ hours and of the larvae of the lesser bulb flies (*Eumerus* spp.) with treatment for one half hour at a temperature of 111° F. For safe, practical application, however, the duration should be 2 hours. This treatment has now been authorized by the Bureau of Plant Quarantine as an alternate method for treating bulbs infested with bulb-fly larvae to meet the conditions imposed by the bulb-quarantine regulations on interstate shipments of bulbs.

The results of this year's studies with field-grown stocks indicate that practically all classes of hardy narcissus tolerate the treatment at 111° F. for 4 hours, provided it is done after a week or more of curing, following digging, and before the bulbs show root or leaf growth. Field-grown stocks appeared to be stimulated by the treatment, since an increase in yield over that of the untreated bulbs was noticed. Under conditions of the Pacific Northwest the treatment of forcing stock must be done in quantities small enough to avoid exceeding a 2-hour approach period, and with a heating period of 2 hours at 111° . Higher temperature limits appeared possible for the stocks grown at Babylon, N.Y. Fumigation with sodium cyanide between August 1 and September 15 showed no detrimental effects on the growth of bulbs in the field, nor was there any particular seasonal variation noted.

MUSHROOM INSECTS

Investigations conducted cooperatively with the Bureau of Chemistry and Soils have shown that calcium cyanide when used as a fumigant in mushroom houses at peak heat reached maximum concentration (7.5 to 8.4 mg per liter) within 15 minutes and that concentration of the gas decreases almost as rapidly. The rapid absorption of the gas is due to the combination of high temperature and excessive moisture. The higher concentration was obtained with less material when sodium cyanide was used in the "pot" method, but the gas was taken out of the air just as rapidly.

Experiments with composting manure heaps conducted in cooperation with the Bureau of Plant Industry clearly showed that the central portions of the heaps are too hot for pests to survive. Proper ventilation of the heaps at ground level raises the temperature in the lower part of the pile to a point fatal to insects.

COTTON INSECTS

Investigations on insects attacking the cotton plant were conducted under the direction of R. W. Harned.

BOLLWEEVIL

The records of field-plat tests of the current season will not be available until the cotton has matured and the yield records of experimental plats and fields have been obtained. Preliminary examinations indicate a range of from 150 to 250 pounds per acre of gain from poison dusting. The mixture of lime and calcium arsenate in equal parts, which is again being tested in South Carolina, indicates, in field tests, results about as satisfactory as those from calcium arsenate alone, but comparable cage tests with this mixture indicate a 50-percent kill as opposed to a 77.5-percent kill with calcium arsenate alone. Cage tests with three different brands of calcium arsenate indicate considerable variation in effectiveness, the mortality ranging from 68.7 to 77.5 percent and 85.5 percent, with 7 to 12 percent mortality in check cages.

A special line of experiments are under way this year involving comparison of dry mixtures of 25 percent paris green and 75 percent calcium arsenate with wet mixtures, both being factory products. The results of field tests are not available but the cage tests indicate a higher toxicity with the dry than with the wet mixture. This reverses results of previous tests, but this year probably a much better mixture was secured through more accurate factory mixing.

As appropriate to a fiscal-year report, the following record deals largely with the results of experimental work available in the fall of 1932: The early season indications of severe bollweevil damage for 1932 following the very

mild winter of 1931-32 were borne out by the Bureau of Agricultural Economics' estimated loss of 15.2 percent by this insect—the greatest damage reported since 1927. In only 5 previous years, 1920, 1921, 1922, 1923, and 1927, has the weevil destroyed so much cotton. In Virginia the weevils caused a greater reduction in yield than during any previous year, while in Tennessee, Georgia, Alabama, and Mississippi the yield was reduced more than in any year since 1923. As a result of this heavy infestation an unusually large number of weevils entered hibernation in the fall of 1932. The spring (1933) Spanish-moss examinations in 4 States and the hibernation cages located in 6 States showed a survival lower than usual except in South Carolina. However, the weevils entered hibernation in such abundance in the fall of 1932 that in spite of the heavy winter mortality enough survived to cause a large initial weevil population in the spring of 1933. This outlook for a second year of heavy damage was changed in many sections by the excessively hot, dry weather in June and July, which effectively checked weevil development. This year's infestation in general has been average but characterized by much variation or "spottiness", caused to a large extent by localized rains.

NEW AREAS INFESTED

Conditions were favorable for the spread of the bollweevil into new territory during both 1931 and 1932. Scouting in November 1932 showed that the line indicating both the limits of commercial cotton production and the bollweevil in Virginia is from 30 to 50 miles north of the previously reported bollweevil-infested area. The northernmost point of known occurrence of the bollweevil in the United States is Sweet Hall on the Pamunkey River, about 9 miles north of West Point, Va. This is slightly farther north than the weevil has been reported in southern Kansas and southern Missouri. In northwestern Oklahoma, Woodward County became infested with bollweevils for the first time in 1932 and weevils were found farther north than they had previously been recorded in the counties of Dewey, Major, Alfalfa, Grant, and Kay. In all of these counties the weevils reached the northern limits of commercial cotton production, as was also the case in Chautauqua and Montgomery Counties, Kans.

CONTROL

Bollweevil investigations were continued at Tallulah, La., and also in Oklahoma, South Carolina, and Texas, in cooperation with the experiment stations of those States.

All the series of plats in different localities dusted with calcium arsenate after 10-percent infestation had been reached—this being an index to the time for applying weevil control—gave sufficient increase in yield to show a profit from dusting, even with the low prices of cotton prevailing in 1932. The calcium-arsenate-dusted plats at Florence, S.C., gave a gain of 176 pounds of seed cotton per acre, or 23 percent increase over the checks; at Tallulah, La., the gain was 572 pounds of seed cotton, or 46 percent increase; while at Eufaula, Okla., the gain was 651 pounds of seed cotton, or 111 percent increase.

Farmers, in attempting to apply poison when the 10 percent index has been reached often find, especially following the more active field migration of weevils in the summer, that the square infestation may range up to 90 percent. In order to determine the possibilities of control under such conditions two tests were made at Tallulah during the summer of 1932 on very fertile land where the cotton could be expected to continue fruiting until late in the season. In the fields selected, weevil activity had been such that only a very light crop of bottom bolls had set. The first test concerned an area where more than 87 percent of the squares had been punctured. Beginning July 19, 14 applications were made of calcium arsenate, each averaging more than 7 pounds to the acre. Although at no time during the test was square infestation brought below 20 percent, yet the yield per acre in the treated plat was 2,126 pounds of seed cotton as compared to 507 pounds in the check plat, an increase of over 319 percent, or, on the basis of cotton at 5 cents per pound, a profit of \$22.11 per acre above all expenses. In the second test, started on August 4, when 88 percent of the squares were punctured, 9 applications of calcium arsenate averaging more than 6 pounds to the acre per application were made, and although the square infestation was never brought below 37 percent yet the yield per acre in the treated plat was 1.896

pounds of seed cotton as compared to 1,079 pounds in the check plat, an increase of 817 pounds, or over 75 percent, or a profit of \$10.48 per acre with cotton at 5 cents.

Tests in Oklahoma and South Carolina again showed that dependence upon the use of 1-1-1 molasses-calcium arsenate mixture alone does not give satisfactory bollweevil control. However, in 1932 when weevils were abundant early in the season the combination of early poisoning with the 1-1-1 molasses mixture followed by calcium arsenate dust after 10 percent infestation averaged slightly more economical gains in both States than any other treatment.

In Oklahoma one presquare application of the molasses mixture followed by calcium arsenate dust as needed after 10 percent infestation gave an average increase of 560 pounds of seed cotton per acre, or 82 percent increase. In South Carolina three early applications of the 1-1-1 mixture and five later applications of calcium arsenate dust after 10 percent infestation produced an average gain of 366 pounds of seed cotton per acre, or 65 percent increase. The use of molasses-mixture applications in South Carolina seems to have a tendency to reduce the early plant-lice infestations which sometimes follow cotton dusting for bollweevil control.

In South Carolina, where arsenical injury occurs on certain sandy soils from the use of excessive quantities of calcium arsenate, particular attention is being paid to methods of reducing the total quantity of calcium arsenate necessary for weevil control by presquare applications of molasses mixture and by mixing builders' lime with the calcium arsenate. Tests at Florence, S.C., in 1932, using a mixture of builders' lime and calcium arsenate in equal parts for bollweevil control, gave about as good results as calcium arsenate alone.

In view of the pending legislation requiring that arsenical insecticides be colored as protection against accidental use in food, the Manufacturing Chemists Association of the United States requested that tests be made to determine the effect upon insects and cotton plants of the addition of coloring agents in calcium arsenate. In a large series of cage tests at Tallulah, La., and Bryan, Tex., and field-plat tests at Tallulah and Florence no appreciable difference was noted between the colored and standard white calcium arsenates supplied by the different manufacturers.

In a preliminary study of bollweevil parasites in Madison Parish, La., during 1932, parasitization at its highest averaged slightly less than 10 percent. About 90 percent of the parasites were *Microbracon mellitor* Say. Other species reared were *Catolaccus incertus* Ashm., *C. hunteri* Cwfd., *Eurytoma tylodermatis* Ashm., and *Eupelmus cyaniceps* Ashm. These studies have been continued during 1933 at Tallulah and also at Natchez, Miss., where field experiments are in progress in an effort to develop a method of making practical use of parasites in bollweevil control.

HOST PLANTS

On account of the importance of host plants other than cotton in any bollweevil-eradication plan, investigations of this subject were resumed at Tallulah in 1932 and continued again this year. Freshly emerged cotton-bred weevils before they had fed were caged with a number of malvaceous plants. On only one of these, althea (*Hibiscus syriacus* L.), were weevils reared to maturity. On this plant the weevils reached maturity, deposited eggs normally in the flower buds, and three female weevils developed and emerged from the buds in 1932, and in 1933 10 weevils had emerged by September 2. In 1933 althea was planted among cotton on the laboratory grounds, and during August 6 weevils emerged from buds collected from these plants. This is particularly important, as it is the first record of bollweevils breeding under natural field conditions on a host plant other than cotton and *Thurberia*. Tests with other possible host plants were all negative although bollweevil eggs were deposited externally on the seed pods of *Hibiscus militaris* Cav. and *H. lasiocarpus* Cav. The larvae hatching from these eggs were placed in seed pods of those plants but soon died without feeding. No eggs were deposited on hollyhock (*Althea rosea* Cav.) or okra (*Hibiscus esculentus* L.). The only previous record of bollweevils developing in plants other than cotton or *Thurberia* was made at Victoria, Tex., in 1913, when two males were reared under cage conditions from this same althea.

Experiments to obtain an attractant for the bollweevil have been continued but no material has yet been discovered that gives promise of being of value.

THURBERIA WEEVIL

Studies of *Thurberia* weevils which have been removed from their native host plant and bred continuously on cotton to note changes in habits and adaptability over a period of years are now in their seventh year and indicate that the weevils are becoming more adapted to cotton. There are two or more generations annually on cotton, probably because of the longer fruiting season, instead of one generation as on *Thurberia*. The *Thurberia* weevils bred on cotton show a decided preference for bolls, whereas squares are preferred by the bollweevil. Fortunately the *Thurberia* weevils retain their original habits of hibernating as adults within the pupal cells in cotton bolls, instead of emerging and seeking shelter, as does the bollweevil. This habit confines the hibernating weevils to the cotton fields and makes possible control by clean-up and sanitary field conditions. The survival is many times higher, however, than it is for the bollweevil.

The damage to the 1932 crop of cotton in the Santa Cruz Valley of Arizona was much less than for the previous year. The low infestation was due to the fact that most of the weevils from the previous crop had either been destroyed or caused to emerge from hibernation by cultivation and irrigation early in the season before cotton was available, and to the fact that there were no summer flood waters to wash infested *Thurberia* bolls down from the mountains. The damage last year to an isolated planting of Pima cotton in close proximity to mountains with infested *Thurberia* was the greatest observed during the 3 years since it has been under observation, the infestation averaging, by the end of the season, over 40 percent of the bolls. All of the evidence indicates that the *Thurberia* weevil readily transfers from *Thurberia* to cotton under the conditions found in the principal cotton-producing areas of southeastern Arizona.

BOLLWORM

The bollworm did not cause so much damage to the 1932 crop in most sections as usual, but in 1933 the damage was above normal over large areas. Studies of the causes of its sporadic abundance, which are being continued in cooperation with the Texas Agricultural Experiment Station, indicate that the physical condition of the cotton plant is an important factor in determining the degree of infestation. On the more succulent, fast-growing cotton, more eggs are deposited, a larger percentage hatch, and more young larvae are successful in entering the bolls. The loss in both eggs and newly hatched larvae is heavy from dislodgement by mechanical agencies; and while parasites and predators destroy some, they were not so important as the mechanical agencies in destroying the eggs under observation at Spur, Tex., and the Brazos bottoms in 1932. Careful records on four varieties of cotton showed no varietal difference in infestation. In toxicity tests with several kinds of colored calcium arsenate the standard white and colored samples were equal in killing the bollworm.

COTTON FLEA HOPPER

Field headquarters for investigations of the cotton flea hopper and related insects were moved during 1933 from Tallulah, La., to Port Lavaca, Tex., in response to an appeal from planters and business men of the Texas Gulf coast district for assistance in controlling these insects following severe damage in 1932. The damage by the flea hopper is an annual occurrence in this section, and with the splendid local cooperation good opportunities for field-control experiments are available.

The results of last season's work under controlled cage conditions at Tallulah proved definitely that the damage caused by the cotton flea hopper is principally to small squares (flower buds just as they are formed), with occasional slight damage to large squares, whereas the tarnished plant bug and the cotton plant bug injure and cause shedding of large squares and bolls as well as small squares.

Cage toxicity tests in 1932 with sodium fluosilicate and field tests in 1933 with the fluosilicates of sodium and barium gave good control. These fluorine compounds, however, are not altogether satisfactory for applications as dusts and also have caused some injury to foliage. Sulphur is as effective in killing the nymphs but is less toxic to the adults and is slower in killing than the fluosilicates. Dusting with sulphur in field tests at Port Lavaca in 1933 gave

fairly high percentage control against the flea hopper, amounting to an increase of 248.3 pounds of seed cotton per acre, or nearly a 40 percent increase over the check. Several other insecticides were tested on a field basis this year but the yield records are not yet available. Derris root (2.4 percent rotenone) gave a good kill of the tarnished plant bug and acts very quickly but was not so effective against the flea hopper.

Studies of host plants at Port Lavaca show that goatweed (*Croton* spp.) is by far the most important plant for fall oviposition and winter carry-over of flea-hopper eggs and that relatively few pass the winter in cotton stalks. Rain greatly stimulates hatching of the overwintering eggs which extends well into the summer. Horsemint is the most important early-spring plant for breeding flea hoppers in eastern Texas and an enormous population is bred up on this plant which migrates to cotton when the plants reach maturity during May. Sweeping records, flight screens, and field inspections showed a continuous migration from weeds to early cotton, with heavy migrations during periods of rain and high winds. The large areas on which the principal spring and fall host plants, horsemint and croton, grow are important factors in producing severe hopper damage in this section and suggest possible control by reducing the host plants which carry the flea hopper through the winter and spring months.

PINK BOLLWORM

The cooperative investigations of the biology and control methods for the pink bollworm have been continued with the Texas Agricultural Experiment Station and with the Defensa Agricola of the Mexican Department of Agriculture. The station at El Paso, Tex., was closed on June 30, 1933, and Presidio, Tex., is now field headquarters for all of this Bureau's investigations of the pink bollworm.

Calcium arsenate, sulphur, calcium cyanide, nicotine sulphate, and sodium fluosilicate gave some indications of control in 1932 and further tests with these and other insecticides are being conducted this year.

Six chemicals—oil of anise, terpinyl acetate, trimethylamine, ammonium hydroxide, gossypol acetate, and ethyl cinnamate—which have been used as baits for other insects were tested as attractants for the early emerged pink bollworm moths at Presidio this spring, all with negative results.

The parasites *Microbracon brevicornis* Wesm. and *Exeristes roborator* Fab. readily attacked the pink bollworm and were easily bred in the laboratory. A special air-conditioned insectary has been constructed at Presidio for the work of rearing parasites in quantity for release in the fields. The first field liberation of *M. brevicornis* made last October at Presidio apparently did not become established. A shipment of this species was made in July 1933 for release in the fields of the Laguna district of Mexico where the pink-bollworm infestation builds up earlier in the season than in Texas. Native parasites were found attacking the pink bollworm in the vicinity of Presidio for the first time in the spring of 1933. *Microbracon mellitor* Say, *M. platynotae* Cush., *Elasmus setosiscutellatus* Cwfd., *Zatropis incertus* Ashm., and *Perisierola* sp. were reared from pink bollworms, for the most part from larvae feeding in the blooms. None of these species was very abundant. A disease of the larvae has been identified by G. F. White as a septicemia caused by a bacillus, possibly new. While prevalent under laboratory conditions the occurrence of this disease in the field has not been determined.

Field tests of cultural-control methods and development of special machinery for the clean-up of cotton fields were continued in cooperation with the Bureau of Agricultural Engineering. Early winter plowing and irrigation of a 50-acre field caused a heavy mortality of overwintering larvae but the area was not large enough to prevent the infiltration of moths from surrounding fields building up a heavy infestation. Need for a more efficient and cheaper method of cleaning up infested cotton fields has led to the designing and testing of an improved pusher type of stalk shaver which seems promising.

The survival from hibernating larvae under various conditions both at Presidio and Tlahualilo was greater in the spring of 1933 than for the past several years. This accounts for the present indications that the infestation in the Big Bend country will be about the same as last year despite the smaller number remaining in the fields last fall after the floods and clean-up of fields had destroyed a large part of the larvae.

The area infested with the pink bollworm has changed but little since last year. Shortly after the discovery of this insect in southern Florida in the

spring of 1932, the finding of light infestations in the northern part of the State caused considerable alarm. Thorough surveys by the Bureau of Plant Quarantine and State officials showed that the infestation was limited to several counties near the Georgia line and did not extend into the more important cotton areas of the adjoining States. Prompt and vigorous eradication measures were taken by the Bureau of Plant Quarantine and up to September 1933 no recurrence had been found. Surveys made by the Bureau of Plant Quarantine with the Bureau of Entomology cooperating revealed more wild cotton than was anticipated and a rather general infestation of the pink bollworm in the wild-cotton-growing areas on the mainland and adjoining keys from Miami southward and westward along the coastline as far north as Tampa. The Bureau of Plant Quarantine is making good progress in cleaning up the wild cotton in the areas of known pink-bollworm infestation in order to eliminate or greatly reduce the danger of natural spread or carriage by man to the commercial cotton-growing areas in the northern part of the State.

Eradication from the Salt River Valley of Arizona apparently has been successful, as no infestation was found in this area in 1932-33, while the known infestations have not increased in size in other parts of Arizona, New Mexico, and Texas. No new areas of infestation in the Rio Grande Valley have been reported as a result of the two heavy floods last fall which carried infested seed cotton from the Big Bend area southward.

INSECTS AFFECTING FORESTS, INCLUDING THE GYPSY MOTH AND OTHER MOTHS

The work in this division is under the direction of F. C. Craighead.

An important activity of the Division of Forest Insects is its cooperation in pest control with the several Government agencies administering timberlands, viz, the Forest Service, Park Service, Indian Service, and the Civilian Conservation Corps. Private owners were also helped to a less degree. For the most part, this cooperation consists in surveys of bark-beetle infestations, estimating the losses, making recommendations as to methods of control and furnishing estimates as to costs of such operations. In some of the projects it has been possible to assign a forest-insect specialist to train the personnel of these agencies and to advise on technical matters arising in the course of the work.

WESTERN BARK BEETLES

The most destructive forest insects, especially in the western forests, are bark beetles. Several of the more important of these have been under investigation for years, but during the past year new developments have given promise of real service in aiding in the control of these pests.

One of these developments has been the killing of from 25 to 92 percent of the overwintering brood of bark beetles in the pine region of eastern Oregon and Washington, northern California, and the northern Rocky Mountain forests. Mortality of these broods in the larval stage from freezing has been recorded only a few times in the past and never before has been noted over such a large area or to such a degree. The effects of this excessive and continued cold period of the winter of 1932-33, involving temperatures of from -20° to -50° F., indicated the importance of this phase of control, which from time to time must have had large influence in reducing the numbers of bark beetles and other forest pests. Fortunately the Bureau was able, during the cold period, to make studies of the relation of exposure, bark thickness, and air temperatures to beetle control. These studies were aided by laboratory investigations made some years ago at the California station, at which low temperatures fatal to pine beetles had been determined. The killing of overwintering broods has made it possible to abandon various control projects which had been planned and to discontinue others which were under way.

THE WESTERN PINE BEETLE

During the 1932 season the infestation of the western pine beetle declined somewhat in California but reached its peak in eastern Oregon and Washington. The low temperatures just discussed were particularly useful in reducing the overwintering broods of this bark beetle in Washington, Oregon, and northeastern California. In other parts of California it still exhibited

epidemic tendencies, the effects of the freeze being irregular and apparently altogether lacking in the central Sierra Nevada region. Some eight control projects directed against the western pine beetle, but including some other bark beetles, were carried out in California this year. These involved expenditures, by the forest agencies concerned, totaling \$120,000.

MOUNTAIN PINE BEETLE

The mountain pine beetle, although still very injurious in much of its range in the northern Pacific and Rocky Mountain forests, suffered a high mortality in many of the forests from the excessive cold of last winter. This may perhaps make possible the reopening of several control projects formerly abandoned as hopeless.

Improvements have been made in control methods by means of which it is believed that many of the parasites and other beneficial insects which have hitherto been destroyed along with the bark beetles may be protected and saved. This should aid in maintaining the natural balance between such beneficial insects and bark beetles and lessen the likelihood of serious outbreaks of the latter.

An effort to control serious outbreaks of the mountain pine beetle has been under way over a period of years in several areas, and, as to some of these, substantial success has been reached during the past season. After many years of effort, complete control of this beetle in the pine forests of Crater Lake National Park has been achieved. Last year 20,311 infested trees were found and treated on an area of 30,000 acres. This spring only 6,163 infested trees were found on the same area and these were disposed of by workers of the Civilian Conservation Corps. A 2-day inspection following this work failed to disclose any infestation.

Four seasons of artificial control directed against an outbreak of the mountain pine beetle in the highly prized commercial white-pine stands of the Coeur d'Alene National Forest were completed during June 1933. This is the largest bark-beetle-control project ever undertaken, having been instituted in 1930 under an appropriation to the Forest Service of \$150,000. During the past three seasons additional expenditures amounting to \$120,000 have been made in conducting clean-up work. As a result of this expenditure the valuable white-pine stands of the Coeur d'Alene National Forest, totaling some 900,000,000 board feet, have been preserved from seemingly inevitable destruction.

A similar project which has been under way for the past 5 years on the Kootenai National Forest, involving an expenditure of \$75,000, has also resulted in the preservation of valuable commercial timber stands. During the past season bark-beetle control projects against outbreaks of the mountain-pine beetle were also conducted in the Yellowstone, Teton, and Mount Rainier National Parks, and in the Wyoming, Cache, Medicine Bow, and Montezuma National Forests.

Infestations of the mountain pine beetle in sugar pine have been increasing for the past two seasons in the central Sierra Nevada region. Losses continue heavy except on those areas where direct control measures have been initiated. In some areas the 1932 losses were found to run as high as 1,000,000 board feet to the timbered section. The heavy precipitation which occurred in this region during the winter of 1931-32 did not contribute toward any general check of this insect.

EASTERN WORK

SOUTHERN PINE BEETLE

The southern pine beetle was active in the Coastal Plain from southern Pennsylvania to Georgia. In the northern portion of its range, from southern Pennsylvania to Virginia, it was more destructive than at any time during the last 40 years. One of the most serious infestations was in Fairfax County, Va., where 7,500,000 board feet of short-leaf pine timber and some 30,000 cords of pulpwood have been destroyed.

MEDICATING TREES

Investigative work has been continued with special reference to the development of the best technic for medicating trees by the injection method.

Promising results have been obtained in injecting insect-destroying poisons into trees infested by bark beetles and a simplified and more efficient method has been devised. This technic, which takes advantage of the natural forces causing the rise of sap in living trees, has also been used successfully in injecting preservatives into such trees. It is hoped that by this method trees which will later be felled and utilized will be more cheaply and effectively impregnated with the preservative.

Encouraging results have also been obtained from spraying the bark of infested trees with a substance that will penetrate and kill the borers. To date certain oils and orthodichlorobenzene have been found most effective.

LOCUST BORER

In the investigation of the locust borer, in Tennessee, Kentucky, Indiana, Illinois, Ohio, Michigan, Pennsylvania, and New York, special emphasis has been placed this year on soil studies inasmuch as tree vigor seems to be the dominant factor in lessening injury; hence character of soils may have a very important bearing on the problem. The important soil factors, as affecting the locust, appear to be compactness, organic matter, and drainage.

FOREIGN WORK

One entomologist with headquarters in Budapest, Hungary, has been engaged in securing and shipping to the Melrose Highlands, Mass., station parasites of the European pine-shoot moth, the larch case bearer, the satin moth, the elm leaf beetle, and the sawfly *Phyllotoma nemorata* Fall. that mines the leaves of the birch. All of these destructive insects have gained entrance into the United States from foreign countries, and efforts are being made to establish in this country as many as possible of the parasites that attack them abroad. In the case of the first three mentioned, this work is of comparatively recent inception, having been started in 1930 or later. It is therefore too early to judge the results or even to indicate what parasites have become established.

Information is being secured also regarding the distribution and natural enemies of the beech scale in Europe. Several predators have been noted feeding on this scale, but more information is desired regarding them before attempts are made to establish any of them in New England.

LIBERATION AND RECOVERIES OF PARASITES

Approximately 6,000 females of a tachinid fly (*Phorocera agilis* R. D.) and about half that number of males were liberated in two gypsy-moth infestations in Massachusetts. These flies issued from puparia received in 1932 from Europe, where this fly is an important enemy of the gypsy moth. No puparia were imported this year, since it was thought that the fly has been given sufficient opportunity to establish itself through liberations made during the past several years. That some establishment has been effected is indicated by its recovery during the past few years.

This season 1,650 females of *Rogas unicolor* Nees, a hymenopterous parasite of the satin moth, were received from Europe and put out in New England. The first introduction of this species concerned a few adults received in 1932. Apparently males seldom occur, but laboratory studies have shown that the species is able to reproduce parthenogenetically. The prospects for the establishment of this parasite are promising, since it requires no host other than the satin moth for its development.

The most important feature of the work with European-pine-shoot-moth parasites was the large number of two hymenopterons received from Austria and liberated in Massachusetts, Connecticut, New York, and Pennsylvania. A total of 121,450 adults of *Tetrastichus turionum* Hart. and 156,500 adults of *Copidosoma geniculatum* Dal. were put out, and collections of the host made later showed that the former species had passed through a generation in the field.

For the first time worth-while colonies of the parasites of the birch sawfly (*Phyllotoma nemorata* Fall.) were liberated this year, when a total of 1,300 females of *Chrysocharis* sp. and 500 females of *Phanomeris phyllotomae* Mues., obtained from material sent from Europe, were placed in the field in Maine.

Larch-case-bearer parasites were received from Austria and colonies of three species were put out. In the case of two species the numbers liberated were

small, but a total of 1,399 males and 1,639 females of the third species (*Chrysocharis laricinella* Ratz.) were liberated in Maine, New York, and Massachusetts. A generation of this parasite was reared at the station on small potted larch trees which were artificially infested by the case bearer by putting moths in cellophane bags that enclosed the trees. Later the parasites were allowed access to the case-bearer larvae by placing them in the same bags.

Two species of Hymenoptera parasitic on the eggs of the elm leaf beetle were received from Europe and approximately 1,300 adults were put out in California, Ohio, Virginia, the District of Columbia, and Massachusetts. A large percentage of these adults were *Tetrastichus xanthomelaenae* Rond., the remainder belonging to an undetermined species of the same genus.

The usual sample collections of eggs, larvae, and pupae of the gypsy moth, and of larvae of the satin moth and the brown-tail moth, have been made at designated points in New England to obtain information regarding the effectiveness of parasites that have been imported in the past and are now firmly established. The gypsy moth has been markedly more abundant this year than for the past few years, particularly in southeastern Massachusetts. Generally speaking, the percentage of parasitization of this pest is somewhat lower than last year, although, as usual, the sample collections indicate that the percentage of individuals killed by parasites differs in different sections of the infested area.

It is of interest that four of the enemies of the gypsy moth that were introduced from Europe into New England have been found in the gypsy-moth infestation discovered last year in the vicinity of Pittston, Pa. These four species are the predacious beetle *Calosoma sycophanta* L., two tachinid flies (*Sturmia scutellata* R. D. and *Compsilura concinnata* Meig.), and a hymenopteron (*Apanteles melanoscelus* Ratz.).

GYPSY-MOTH ATTRACTANTS

Experiments with attractants that may be used in traps to catch male gypsy moths have been continued. Such attractants are now prepared by clipping off the last three abdominal segments of live virgin female moths and preparing an extract from them in such solvents as xylene, benzene, or gasoline. Traps baited with these extracts have proved of practical value in locating isolated infestations of the moth. The attempt is being made to increase the efficiency of the attractant and trap by improved methods of obtaining, preparing, and storing the extracts and of utilizing them in the field. This year it has been found that the extract, instead of being stored as such, can be poured on to cotton, evaporated, and the cotton stored without any material loss of the attractant. Tests have also shown that the cotton or other absorbent containing the attractant after having been used in traps one season can be stored in a solvent and used again the next season with a loss of only about one half of its attracting power. At present the female moths used in securing the attractant are usually obtained from pupae collected in the field. Where the work is done on a large scale the limited period during which pupae can be collected is a hindrance. To lengthen the collecting period, large female larvae have been collected in numbers and placed in screened cages, where they are fed and allowed to pupate.

INSECTICIDES

The study of possibilities of control of the beech scale by application of various insecticides has been continued. Previous field experiments had indicated that spraying with miscible oils in the late fall was injurious to the growth but that early spring applications could be made safely. It has now been found that certain miscible oils injure beeches even when applied in the early spring. Spraying with concentrated lime-sulphur at the rate of 9 gallons to 91 gallons of water in the early spring gave 100-percent control of the scale and as yet no injury to the trees has been observed. In tests with nursery stock, a commercial mixture of ethylene oxide with carbon dioxide (proportions approximately 1 to 9) gave promising results when used against both the beech scale and hibernating satin-moth larvae, but further experiments must be conducted before definite conclusions can be drawn. In connection with the beech scale, additional scouting this spring has shown that the insect is widely distributed in southeastern Maine, involving many heavy infestations. This scale has also been found in towns in southwestern Maine and southeastern New

Hampshire. These infested areas were not located when previous scouting was done in 1931 and when the scale was found to occur in Liberty, Maine, in the North Shore section of northeastern Massachusetts, and in Boston, Mass., and neighboring towns and cities.

Of the materials tested for the control of the larch case bearer, concentrated lime-sulphur applied as a dormant spray gave the best results while only fair results were obtained with the various spray mixtures used in experiments for the control of the European pine shoot moth. Of the nonarsenical stomach poisons tested against gipsy-moth larvae malachite green gave the most promising results.

FOOD-PLANT PREFERENCE OF GYPSY-MOTH LARVAE

This year a number of tray experiments were conducted in which gipsy-moth larvae were given different types of foliage. In some trays the same type of foliage was used throughout the tests, while in others different types were substituted after the larvae had passed through part of their instars. Some of the trays gave interesting results which in a few cases were at variance with results obtained in tests of a similar nature conducted about 20 years ago. Such experiments may finally help to solve the problem of why the gypsy moth is seldom if ever noticeably abundant in certain areas while in others it is more or less a continuing pest.

INSECTS AFFECTING STORED PRODUCTS

The work on insects affecting stored products is conducted under the direction of E. A. Back.

PEA WEEVIL

The pea weevil is recognized as the chief drawback to the continued success of field-pea crops throughout the Palouse area of Washington and Idaho—hence the increased interest in, and appreciation of, work of this Bureau by growers and contractors. The establishment, also, of Federal grades for field peas, which place special emphasis on weevil damage, has still further stimulated the interest in control measures on the part of growers.

The possibility of attracting weevils returning from winter hibernation to early planted trap borders has been under experimental test during the last 2 years. That such trap rows are effective in concentrating and holding the weevils for a considerable period has been demonstrated during the last season. For example, it was possible to collect from trap rows, about the middle of June, nearly 1,500 weevils in 100 sweepings of the net as opposed to 8 weevils in a like number of sweepings alongside in the later-maturing vines of the field. Naturally this ratio changed as the field vines came into bloom. To give such border concentration a control phase it follows that it is necessary to develop some means of destroying the weevils while on these border plants. Experiments to determine such possibilities were started early in 1933, but no results of practical advantage to the grower have so far been obtained.

It becomes increasingly apparent to the growers that the burning of pea vines on the field after threshing offers a valuable means of weevil control, even though certain fertilizing values of the vines if plowed under are thereby lost. The data on the benefit from burning as to the crop of 1933 are not available, but studies made in the Willamette Valley in 1932 indicate that in fields left unburned the previous year infestation increased some 25 percent over that of burned fields. During the past season a community effort in such burning was undertaken at Barlow, Oreg., in the Willamette Valley. Sixteen small fields totaling some 200 acres were burned after harvest, all of the growers in the neighborhood uniting in this effort. Under normal conditions a good demonstration as to the value of this method should result with the crop of 1934.

Airplane dusting of pea fields with calcium arsenate during May 1932 and June 1933 has not demonstrated any great value. Nevertheless several prominent pea growers were so impressed with the possibility of such control that they have determined to continue tests another year.

The extremely low temperatures of the 1932-33 winter, previously referred to in connection with bark beetles in the northwestern forests, caused a very high mortality among hibernating pea weevils in the Palouse area, with the

result that the 1933 crop has been relatively free from damage. From studies conducted by the Bureau on winter shelters of cage type it developed that a temperature of -2° F. was fatal to all the weevils in such cages in this area, and also in the Willamette Valley in Oregon. Weevils in cages better protected by grass and snow survived in very small percentages at a temperature of -13° at Emmett, Idaho, at -23° at Ames, Iowa, and at -18° at Moscow, Idaho. Similar mortality was found in weevils hibernating in cracks in fence posts and high mortality of less extent was determined in weevils that had sought shelter beneath the bark of ponderosa pines. Similar studies made during the preceding, much milder winter revealed little killing effect on hibernating weevils.

Notable among the new facts determined in 1933 is that adult weevils can remain dormant in harvested peas over two crop years and then emerge without loss of vigor or fertility. A second important addition to our knowledge of the biology of the pea weevil is the fact that it may have a supplemental second generation in a season. It has long been well established that the pea weevil cannot continue to produce generation after generation in dried seeds in storage as in the case of the common bean weevils, but it was determined that weevils emerging from early harvested peas will lay eggs on late-developing peas if such are available, establishing the possibility of two generations annually. An explanation is here afforded of the occasional finding of eggs in abundance on the pods of peas grown late in the season in western Oregon and California for shipment in the green state. This ability to produce two generations a year may become of sufficient importance to require application of additional control measures.

BEAN WEEVILS

On June 30, 1933, the bean-weevil laboratory which has been located at Modesto, Calif., for the past 6 years was discontinued because the investigation was substantially complete except for extension and service features. While this work has been heartily supported by the trade organizations in the affected areas, and while practicable means of substantial prevention of infestation have been developed, it cannot be said that the bean growers, as a whole, have been thoroughly alive to their opportunity for concerted action. At the present time, the degree of infestation in the deliveries is small, yet the percentage of deliveries showing some infestation is so high on receipt at warehouse that fumigation is necessary to prevent the crop from going rapidly out of condition in storage.

DRIED-FRUIT INSECTS

The personnel of the dried-fruit-insect laboratory at Fresno, Calif., has given special attention to the problem of fig-insect control on ranches. The dried fruit beetle and its close relatives, usually important, have been much less abundant and the raisin moth (*Ephestia figulilella* Greg.) has assumed the major role. That the raisin moth is not likely to prove a serious competitor of the Indian meal moth in injuring dried fruits in storage is indicated by recent studies conducted in orchards and drying yards on the ranches, and in warehouses and at packing plants. Considerable fears of such injury in storage by the raisin moth have been aroused by the tremendous numbers of the larvae of this insect coming from fruits recently delivered from the ranches. Observations on these larvae indicated that they were merely leaving the fruit to seek suitable places for transforming to the moth stage, and that they failed to find in such dried fruits in storage a satisfactory place for the development of succeeding generations. The attacks of the raisin moth on fruits undergoing the drying process on ranches have become the primary factor in reducing the cash returns to the growers—the losses in 1932 having been estimated as about \$216,000 due to lowered quality of figs alone. The raisin moth has been found to infest similarly other drying fruits or dried fruits stacked in orchards or vineyards.

In relation to the injury by the raisin moth discussed above, the Bureau has been concerned during the last two seasons in developing means of protection of drying fruit. The very promising experiments begun in 1932 in protecting drying fruit with tobacco shade cloth have been continued during 1933. These large-scale experiments in fig orchards have indicated that almost complete

protection from such injury may be obtained thus, the fruit thus protected showing little or no infestation as contrasted with infestation running as high as 60 percent in fruit handled under the prevailing drying-yard practices. The general summary of these experiments was considered of sufficient interest by the Dried Fruit Association of California to be published and distributed at the expense of that association. The full reports of the experimental work in 1933 are not yet available.

Some important discoveries in relation to the biology of this pest made during the year give promise of aiding future control efforts. One of these is that the larvae may hibernate in the soil beneath fig trees to continue their development the following season in the first crop of figs. This crop has been considered as unimportant and is commonly harrowed into the soil mulch, where, as now known, the larvae continue their development in the partially desiccated figs to attack later the main fig crop. Another important discovery of the year has been that the raisin moth develops in great numbers in the fruit of mulberry trees grown for shade about many vineyards and fig-packing yards. On an estimate based on sample counts of some 500 pounds of mulberries beneath one such tree, an infestation was shown of over 2,500,000 insects per ton. The mulberry fruit ripens during May and June in advance of the figs, and such infestation must be an important factor in building up large populations of the raisin moth to attack drying peaches, grapes, and figs later in the season.

FLOUR-MILL INSECTS

Insect conditions in the flour mills of the Southwest were worse in 1932 than in 1931, presumably because of the large quantities of grain held in storage. In the mill studies of this year special attention has been given to the degree of penetration of the fumigant to the various parts of cleaned and uncleaned milling equipment. One hundred and fifty-seven box cars which had been accepted by milling companies as being fit carriers for flour were examined for insects, fumigated, and the data tabulated. As might be expected, consistent kills of insects in box cars are not obtained because of the variation in construction and condition of the cars. The results of the examination and fumigation of box cars, as carriers of flour, for 1932 and 1933 are in process of being prepared for publication.

Of special interest during 1933 are the experiments to determine the value of introducing liquid hydrocyanic acid through copper piping directly to the interior of milling equipment, as compared with the present practice of spraying the liquid into the mill space proper. Instead of leaving the machines open so that the fumigant can penetrate them, as has been the practice for years, the newer idea is to introduce the liquid into the interior of the closed machine and permit the vapors to diffuse slowly to the outer spaces of the mill proper. It is believed now that this method of introducing the fumigant places the vapors in greatest concentration where the infestations are apt to be most severe. These experiments, while promising, offer insufficient basis to warrant definite recommendations.

Studies of the biology of the two common species of flour beetles (*Tribolium confusum* Duv. and *T. ferrugineum* Fab.) have been completed during the year. A preliminary paper was published in February 1933 and has been distributed. A technical bulletin giving more complete data has been prepared and is in process of publication. Probably no insects are so generally troublesome to the flour trade as these two species of beetles, yet until these investigations were started very little of the details of their biology was known. Of special interest to shippers and others is the fact that both of these beetles seem able to survive as adults for over 2 years. Adults of *Tribolium confusum* held at the usual room temperatures obtaining in a heated office building produced viable eggs for 432 days, the largest number of eggs laid by a *confusum* female being 976. As a rule the beetles lay only 2 or 3 eggs a day although as many as 13 eggs so laid have been counted. At about 80° F. eggs of both species hatched in from 5 to 7 days. These new facts are of practical importance to flour dealers charged with the protection of flour in storage or in settling litigation growing out of insect infestations developing during transit or storage.

Investigations of other flour beetles were started during 1933 and will continue for several years.

GRAIN INSECTS

Very little active research has been conducted during the past year with insects affecting stored grain. Where opportunity has been presented Bureau representatives have attempted to determine the effectiveness of various fumigants used on a commercial scale. Gratifying results have been obtained in fumigations with calcium cyanide, chloropicrin, the ethylene oxide-carbon dioxide mixture, the ethylene dichloride-carbon tetrachloride mixture, and less satisfactory results with propylene dichloride. Of particular interest are the claims made for electricity as a means of destroying insects in grain. While the name of the Federal Bureau of Entomology has been mentioned frequently in connection with such experiments during the past year, the Bureau has conducted no tests that warrant it to take, at this time, a position in favor of treatments of bulk wheat by electricity.

INSECTS AFFECTING CURED TOBACCO

The large-scale fumigation of tobacco storages of the closed type, in the Bright Tobacco Belt, reported upon last year have been continued during the fiscal year covered by this report. The fumigated warehouses have a total capacity of 7,092,099 cubic feet, and contained approximately 42,000,000 pounds of domestic flue-cured tobacco, valued at about \$10,000,000. Five fumigations were conducted in these warehouses under the direction of the Bureau from June to December 1932, a dosage of 10 ounces of liquid cyanide per 1,000 cubic feet of space having been used in most instances. Since the cigarette-beetle infestation was negligible during the 1932 season because of the fumigations conducted during 1931, the main object of the 1932 experiments was to bring about a control of the tobacco moth (*Ephestia elutella* Hbn.). The five fumigations, conducted on June 1, June 28, August 3, September 8, and November 7, respectively, very satisfactorily controlled the tobacco moth. The average cost of these fumigations was 61.2 cents per 1,000 cubic feet of space, or about 48.7 cents per 1,000-pound hogshead of tobacco. Since each hogshead of tobacco is valued at about \$200, this cost for control does not seem excessive. The cost for the fumigations is divided as follows: Liquid cyanide, 81 percent; materials for sealing storage, 4 percent; labor for sealing storage, 6.5 percent; service charge, commercial fumigator, 8.5 percent.

In cooperation with a tobacco concern at Danville, Va., a warehouse containing 484,537 cubic feet, housing 3,500,000 pounds of tobacco valued at \$875,000, was fumigated on June 15 and September 28, 1932, with a dosage of 20 ounces of liquid cyanide per 1,000 cubic feet for a period of 96 hours. Good kills were obtained in test boxes of insects placed 6 inches beneath the staves of the hogsheads, and examinations revealed no living insects. Owing to the migration of beetles from warehouse to warehouse in the same storage area of Danville the fumigated area became infested and the September 28 fumigation was needed. Examinations made following this fumigation showed that few larvae of the cigarette beetle, lodged 6 to 8 inches in the tobacco beneath the staves, had escaped the action of the fumigant.

The migrating habit of the adult cigarette beetle, which urges it to fly from the dark storages to the light and to swarm outdoors around storages, is well known among tobacco men. A flight of unusual numbers occurred in Danville, Va., during the summer of 1933, when citizens of the south side of the city were much annoyed by beetles flying in through windows and penetrating to all parts of their houses.

Recognizing the migrating habit of the cigarette beetle as a fertile factor in vitiating the benefits of fumigation in congested areas, the Bureau, in cooperation with a Danville, Va., tobacco concern, has secured the thorough screening of a large tobacco storage which is being fumigated, to determine to what extent the screening can be depended upon to exclude cigarette beetles once those within the screened storage have been brought under control. This experiment, started in 1933, is still in progress.

Recognizing the research advantages to the Bureau of cooperation with various tobacco concerns conducting private fumigations, the Bureau representatives have endeavored to give assistance wherever possible. It is estimated that during the calendar years 1929-32 97,940,000 cubic feet of tobacco storage in the Bright Tobacco Belt were fumigated with hydrocyanic acid gas. The percentages of yearly increase in fumigated tobacco storage since 1929, the year before these investigations were started, are 145.3 percent for 1930, 85.3 percent for 1931, and 95.4 percent for 1932.

Of special interest to tobacco storages is the suction light trap developed during 1932 in cooperation with H. R. Hanmer, in charge of research of the American Tobacco Co. Mr. Hanmer's original trap, designed for using a combination of suction and light, has been improved upon until an effective trap has been developed, covering which a public-service patent in the names of H. R. Hanmer and W. D. Reed of this Bureau has been applied for through the Solicitor of the Department. From 50 to 85 traps were operated each week from October 1 to December 31, 1932, in the Winston-Salem area, during which period the traps caught an estimated total of 39,487,602 cigarette-beetle adults and 40,885 tobacco-moth adults. In a large open storage warehouse in Richmond, housing "Turkish" tobacco, the average catch per trap for 7 traps during the first week of their operation (August 12-19) was 87,452 cigarette-beetle adults and 348 tobacco moths. During this Richmond experiment, continued from August 12 to December 22, when all insect activity ended in the unheated storages, the 7 to 14 traps in operation captured an estimated 5,454,895 cigarette-beetle adults and 16,023 tobacco-moth adults.

While tobacco concerns have showed their enthusiasm for these suction light traps by constructing and putting into operation considerable numbers during the calendar year 1933, the Bureau experts have been attempting during the past year to determine just how practical a result follows the destruction of such large numbers of insects by means of the traps. The results are not available for this report although accumulating data indicate the practicability of the traps, particularly in the numerous open storages which are not suited to insect control by fumigation. A description and blueprints of the trap are available upon application.

Studies of the biology of the cigarette beetle and of the tobacco moth have been continued during the year and the new information is being made available in correspondence and prepared for publication. A preliminary study of the biology of the tobacco moth was published during the year as Circular No. 269 of the Department.

At the request of the Tobacco Association of the United States, W. D. Reed, in charge of the Richmond laboratory for study of cured-tobacco pests, was authorized to study insects affecting tobacco at points in Greece, Turkey, and Italy where American-owned tobacco is manipulated and stored previous to exportation to the United States. It is recognized that the long storage periods before importation into this country give the cigarette beetle and the tobacco moth ample opportunity to breed to destructive numbers. It is hoped that improved methods of control can be recommended that will be practical under the conditions existing in the storages visited and that in the end the conditions in our own storages will be improved materially as a result of the lessened infestations in imported tobacco following Mr. Reed's trip. Mr. Reed sailed for Athens from New York on July 14, 1933.

HOUSEHOLD INSECTS

During the calendar year 1933 the market has been flooded with cardboard containers in the form of chestlike boxes and closets. These containers usually have been impregnated with oil of cedar or some other oil possessing some insecticidal value when used under certain conditions, or with cedar chips, paradichlorobenzene, or naphthalene. Tests to determine the value of such containers impregnated with cedar oil or cedar chips indicate that they are worthless as protectors against clothes-moth infestation. When the tests were made the cedarized containers were set inside a closet constructed of wall board and containing 130 cubic feet of space. Adult clothes moths were introduced inside the large closet on August 8, 11, and 16, 1933. On September 5, 1933, the cedarized containers were removed from the large closet and opened. Large numbers of adult clothes moths were found inside them and the pieces of woolen cloth fastened to the interior of the containers were heavily infested with clothes-moth larvae which had developed from eggs laid on the cloths by the female moths introduced into the large closet. The larvae had grown well and had caused serious damage to the cloth. These experiments indicate that the clothes-moth adults can readily pass through the cracks about the lids of cardboard containers and that the containers are not sufficiently tight or otherwise conditioned to give protection to clothing against moth injury.

Tests to determine the value of vetiver roots indicate that these roots, although advertised to be of value in protecting clothing stored with them, are

of no value as a protection against clothes moths. Vetivert roots in a box were moistened with water according to directions and placed in a large closet. An uninfested piece of woolen cloth was buried among the roots and 100 adult clothes moths then liberated in the closet. A few days later large numbers of clothes-moth eggs were found deposited on the cloth and a later examination proved that the eggs had hatched and that the larvae were growing happily although surrounded by vetivert roots! It would appear from other tests that if adult moths are given an opportunity to oviposit on cloths perfumed with vetivert extract, or on untreated cloths, they prefer the unperfumed cloths, although if no other cloth is available they will deposit their eggs on the perfumed cloth. Experiments are still in progress.

A study of the food requirements of clothes moths and carpet beetles has been undertaken during the year. It will continue for several years and will include a study of the effect of various dyes upon moth mortality.

The carpet beetle *Anthrenus vorax* Casey continues to increase in the city of Washington. This species is responsible for considerable activity as evidenced by fumigations conducted by local storage and insect-exterminating firms.

The dissemination of information concerning the more common insects of the household, such as clothes moths, carpet beetles, bedbugs, cockroaches, silverfish, furniture pests, and psocids, requires much time on the part of those charged with the work of this office.

INSECTS AFFECTING WOOD

Commercial operators are still exaggerating the extent and seriousness of termite damage to buildings, and the Bureau of Entomology has been making every effort to present the true facts to the public. Leaflet No. 31 of the Bureau has been revised, and reissued as Leaflet No. 101, to make the recommendations for remedying damage to buildings already constructed and for preventing damage to new structures more simple and understandable.

In cooperation with a prominent electrical company large-scale tests of some 40 chemicals, for the control of termites infesting telephone poles, were started during 1933 on Long Island, N.Y. These experiments will be of long duration and have for their object the determination of the value of the chemicals as poisons when applied to the soil about some 400 poles. It is hoped that the data obtained in connection with these tests involving telephone poles will be useful in determining whether or not soil poisons have a practical place in the protection of the foundations of buildings from termite attack.

The experimental work against termites, reported upon last year as being conducted on Barro Colorado Island, Canal Zone, Panama, is being continued and augmented as additional treated woods are included in the termite-resistance tests. At present the tests include woods, variously treated, in the form of stakes, poles, towers, bridges, and even small cottages. These long-time-service tests are being conducted in cooperation with the Forest Products Laboratory of the Forest Service of this Department and the American Wood Preservers' Association. Since termites have been destructive to untreated composition wall and insulating boards, poisoned samples of these wood-pulp and fiber boards have been included in the Panama experiments.

At the request of the War Department an examination, in cooperation with the Forest Service, was made during May 1933 of the arsenals at Rock Island, Ill., New Cumberland, Pa., and Springfield, Mass. A confidential report was submitted on the condition of the buildings and wooden military supplies, and recommendations for correcting insect damage and decay to the buildings and wooden articles stored therein were made. Such examinations have been made once in every 2 or 3 years.

Negotiations are under way to have all Government departments adopt uniform specifications for remedying termite damage to the woodwork of buildings. It is hoped that this will prevent the use of the name of the United States Government in advertising by firms which have treated a few Government buildings and in consequence claim to have received all Government contracts on a noncompetitive basis.

The fourth progress report on the international termite-exposure tests was presented before the annual meeting of the American Wood Preservers' Association held at Chicago in January 1933. Identical treatments that are being tested in Australia, Hawaii, Panama, and South Africa are yielding somewhat different results under these varied environments.

INSECTS AFFECTING MAN AND ANIMALS

Investigations of insects affecting man and animals have been continued under the direction of F. C. Bishopp.

Insects which attack man and animals naturally have wide public interest in both town and country. Work in this field has as its main object the determination of better control methods for such insect pests and in a sense has an important humanitarian aspect in that it may result in increased comfort and happiness to our entire population by lessening the annoyance occasioned by house and stable flies, mosquitoes, and other more directly parasitic types. Similarly, the control of the insect pests and parasitic enemies of domestic animals presents both the feature of abatement of torture from biting insects and also protection against external and internal parasites.

In addition to the important lines of research carried on in this field, an increased effort has been made, in response to requests from individuals or communities, to give information directly applicable to the subject presented rather than, or supplemental to, distribution of publications.

Similarly, an effort has been made through the work of extension entomologists of the Bureau and also by personal contacts with State and local authorities and individuals to secure a coordination of effort and uniformity of procedure in control work. Local, State, and Federal agencies have been urged and encouraged to use available funds for giving employment to the carrying out of needed insect-control projects. In a number of instances assistance has been given to the planning and initiation of such projects.

Of distinct public-service nature, also, has been the investigation by this division of the use of maggots in surgery. This work has made it possible to furnish specific information to laboratories and hospitals on the best methods of rearing and handling sterile maggots.

SCREW WORM AND OTHER BLOWFLIES

These pests are of the greatest economic importance every year in the southwestern livestock-range country, but recently two outbreaks have occurred at considerable distances from this general region, causing serious losses to all types of livestock. The first was in the fall of 1932 in Mississippi and Louisiana and the second in Georgia and Florida, and to a lesser extent in Alabama and Mississippi, during the summer of 1933. Stockmen and others in these areas were unfamiliar with this pest and of the methods of combating it and became greatly alarmed. Drawing on its wide experience with this problem in Texas and other western States, this Bureau, in cooperation with the Bureau of Animal Industry, made, through personal contacts and otherwise, every effort to familiarize county agents, veterinarians, and stock owners with the methods of control, and by this means losses were materially reduced.

The large-scale trapping experiments in Menard County, Tex., described in the last annual report, have been continued. A larger area of range and a few more traps have been used. This method of control of the screw worm continues to show great promise when, at the same time, a rigid system of burning all carcasses on the range is practiced.

Considerable improvement has been made in the manner of baiting the traps in use. The larvicidal values of certain chemical compounds when used in the baits, and their effect on the attraction of the baits for blowflies, have been investigated. Other chemical compounds, which apparently greatly enhance the attracting properties of meat baits, also have been investigated. The results indicate that the dipyridyl oils give very good results as larvicides when used in connection with meat baits. The toxicity of the dipyridyl oils, when used in certain dilutions in meat baits, is slightly less than that of nicotine sulphate, but the cheapness and oviposition-inhibiting characteristics of these oils, as compared with nicotine sulphate, are important and highly desirable factors in their favor.

The data obtained from several tests indicate that the addition of limited quantities of either potassium sulphide or sodium sulphide to meat baits greatly enhances the attraction of the bait. Of the two, potassium sulphide is slightly more attractive than sodium sulphide.

During the past 4 years a study has been made of the predisposing causes of screw-worm attack in relation to eight classes of range animals, viz, sheep, lambs, goats, kids, cattle, calves, horses, and mules. Among sheep 24 such predisposing causes have been established. Arranged in the order of their impor-

tance they are as follows: Needle-grass injuries, fighting, horn-fly attack, shear cuts, accidental injuries, pricklypear, birth, sore mouth, udder injuries, boils, dehorning, beggar lice (seeds), broken horns, rock-bruised feet, brush scratches, wire cuts, old sores, dog bites, hooking injuries by cattle, marking, genitalia injuries, castrating, louse attack, and tick attack. In lambs the number of predisposing causes is 19, in goats 26, in kids 17, in cattle 24, in calves 22, and in horses and mules 14. The investigation has shown that the factors or conditions responsible for several of the common predisposing causes of screw-worm attack in all classes of animals are due to certain common range practices, and can be reduced or eliminated by modifications of the methods in question.

A survey to determine the distribution and seasonal abundance of parasites and predators attacking the screw worm and other blowflies has been continued and extended to new areas. This work has resulted in the determination of new and important parasitic enemies of blowflies and given much additional information of value on the activities of other parasites. Studies have been made also of the many beetles which both in the adult and larval stages feed upon blowfly larvae developing in animal carcasses and thus very greatly aid in the control of this pest. The purpose of this survey is to more accurately determine the control value of these natural agencies with the possibility of increasing their effectiveness.

EYE GNATS

The eye-gnat problem continues to be of decided importance in the Coachella and other valleys in southeastern California and in the Southern States, particularly in Texas and Florida.

Experiments with traps and baits have been continued at Coachella, Calif. That adequate continuous trapping exerts a real control upon the pest is indicated by the effects of the discontinuance of trapping for a short time in the vicinity of the high school in Coachella. At this location the traps had been maintained in working condition for several months. For the purpose of cleaning them they were taken out of operation for 1 week in the first half of April 1932. The abundance of gnats about the school increased sharply and it was not until several weeks after the traps had been again placed in operation that the former status was restored.

Cultural tests indicate that eye gnats breed only in light, loose, freshly worked and moist soils, usually those cropped to truck and fruits, and that few gnats breed in soils with heavy cover crops or with manures turned under in the months of January, February, July, and August. These facts may prove to be a valuable basis of control under some conditions of farm or ranch management. The determination of the fact that eye gnats breed in garbage and excreta makes the prompt and adequate disposal of these very important. Some attention has been given to this subject.

Some preliminary work has been done along the line of applying poisons or repellents to soiling crops as they are turned under. The results show some promise and the enlargement of these tests is contemplated. The possibility of testing insecticides nonpoisonous to higher forms of animal life for control of the gnats in irrigation waters is also under consideration.

MOSQUITOES

During the preceding fiscal year and the first part of this year a cooperative agreement with the International Health Division of the Rockefeller Foundation was in effect under which W. V. King of the Bureau staff made an intensive study of the problem of malaria-carrying mosquitoes in the Philippine Islands. This work has been of supreme importance to the members of the Army units stationed in the islands and to local authorities in pointing the way to more effective malaria control by determination of the species which actually transmit malaria and the concentration of suppressive measures upon them.

In cooperation with the city authorities of Portland and of Multnomah County, Oreg., much antimosquito work was done in the vicinity of Portland, where the flood-water mosquitoes are a most serious pest to people and livestock. In these extensive clearing and draining operations the unemployed were largely used under relief funds.

At the Portland laboratory studies of the life histories, habits, and means of controlling the mosquitoes (*Aedes aldrichi* Dyar and Knab and *A. vexans* Meig.) which breed abundantly in willow flats and cottonwood ridges along the Columbia River have been continued.

A special study of mosquito control has been made in the vicinity of Klamath Falls, Oreg. In that section myriads of mosquitoes are produced in the irrigated hay and grain fields, many of which are several thousand acres in extent. Preliminary recommendations have been submitted for reducing the mosquito pest. These were based upon the manipulation of irrigation water. The report, which was mimeographed by the Department, has been widely distributed in southeastern Oregon by the county agricultural agents.

Following a survey of the mosquito problem at Fort Madison, Wash., a control program was laid out and is being actively prosecuted by local authorities. Additional survey work has been done and recommendations made for mosquito control at Hood River and Tillamook, Oreg., and Ocean Beach, Wash. Considerable work has been done on various oils, arsenicals, and other poisons, including a study of their possible application in mosquito control. These investigations include a rather thorough study of the adaptability of the several oils available in this district. Tests were also made of the effect of various organic oils, acids, and bases, as well as of certain solids, on the spread and toxicity of the oils. It was found that several materials derived from plant products, such as cedar oil, castor oil, powdered rosin, turpentine, pine oil, and coconut oil, increased the spread of the oils, but that such materials as paradichlorobenzene, naphthalene, acetone, caustic soda solution, soap, aniline oil, sodium benzoate, etc., gave no increase and in some instances actually caused a decrease in the spread of the oil film.

Some data have been obtained on the flight range, dispersion, and longevity of *Aedes aldrichi* and *A. vexans*. This has been done by confining a large group of adults and spraying them with methylene blue or eosin. Over a considerable period stained specimens were captured which had flown from 4 to 5 miles and crossed the Columbia River within 10 days from staining. Adults 104 days old have likewise been recaptured.

A very general survey of the States of Washington and Oregon has been made to determine the breeding areas of malaria mosquitoes. This survey was rather intensively carried out in Lane, Linn, and Benton Counties, Oreg. The information thus gained has been assembled for publication with an account of the history of malaria and its present status in these States.

In October 1930 a small number of mosquito-killing fish, *Gambusia* sp., were received from California. These were divided and placed in three or four situations. All were lost with the exception of one lot of 35, which were placed in a small pond on Hayden Island near Portland. These increased to great numbers during 1931 and 1932, and stocks were placed in many localities. In June 1932 Hayden Island was flooded, and predacious fish were washed into the *Gambusia* pond. From that time the numbers of *Gambusia* began to diminish in this pond until at present none remain. These minnows had withstood one very severe winter but were evidently unable to withstand the attacks of small-mouth bass and crappies.

Working from the Orlando, Fla., laboratory as a base, the mosquito survey of Florida, with special reference to malaria-carrying species, has been prosecuted vigorously. In many areas the local authorities have been advised concerning control measures. Activity along this line has been greatly increased since funds allotted by the National Relief Administration have become available for the employment of labor for mosquito-control projects.

The mosquito survey of the Delaware-Maryland-Virginia Peninsula and the west side of Chesapeake Bay, in cooperation with the experiment stations of these States, has been continued. About 30 species of mosquitoes were encountered in this survey. One of these, *Anopheles atropos* Dyar and Knab, had not been previously reported north of the Gulf States.

During the year a three-reel motion-picture film depicting the main features of the biology and control of mosquitoes was completed. This film has aided greatly in the inauguration of mosquito-control projects. The members of the scientific force assigned to mosquito work cooperated with the Office of Motion Pictures in producing the film.

SAND FLIES

During the spring and summer of 1933 much complaint of annoyance from sand flies (*Culicoides* spp.) came to the Department from wooded areas of the Central and Eastern States. Investigation disclosed the fact that certain species of these pests breed in large numbers in rot holes of trees. On account of the close proximity, in many cases, of such tree holes to residences, it appears

that this source of breeding is responsible for much of the sand-fly annoyance in various parts of the country. Experimental tests indicate that such breeding may be eliminated by treating the tree holes once a year with creosote, or creosoted pine sap. Good tree surgery would of course be better still.

The salt-marsh sand flies continue to cause much concern along the entire Atlantic and Gulf coasts. At Fort Pierce, Fla., a diking experiment is giving promise for control of the two most important species of sand flies in the mangrove marshes. From 6 weeks to 2 months after the inundation with river water, small numbers of sand-fly larvae were found along the edge of the water of the diked area. After that time larvae could not be found in such locations. After a period of more than 4 months the water level was allowed to drop about 2 feet. Collections of soil samples from the new edge of the water failed to reveal any larvae, although soil samples from ditches and elsewhere furnished numbers of them.

The finding of concentrations of sand-fly larvae in ditches during the past 2 years appears to indicate that marsh ditches should be used for concentrating such larvae, that ditches in the higher marshes should be extended to flowing streams, and that creosoted pine sap should be used for destruction of larvae in ditch soil.

BUFFALO GNATS

For the past several years an annual outbreak of buffalo gnats in the Delta region of Mississippi and neighboring States has occurred during the early spring months. Death of livestock, particularly mules, from their attack has been frequently reported. To provide reliable information concerning effective remedies and control, investigations have been carried on to this end with the limited funds available. Only a beginning has been possible, but progress has been made on the biology and habits of the pest as a prerequisite to adequate control.

Tests made with repellents for protecting animals from gnat attacks showed a 5-percent pine-tar-oil emulsion to be of value. When gnats were abundant and persistent in their attacks, from 2 to 5 applications of this material were necessary each day to protect the animals. This emulsion is, however, easy to make and apply, can be either sprayed or mopped on the animal, is cheap, and no injury to the animal results from its use as is the case following a heavy coating of tar and grease, the repellent most commonly used in the region.

CATTLE GRUBS

The tests of the efficiency of the ordinary fly sprays in control of cattle grubs have been continued. The results to date indicate that such spraying has no practical value in the control of cattle grubs.

Various insecticides for killing the grubs in the backs of cattle by hand application have been tested. The comparatively new insecticide rotenone, in combination with benzol, was found to be highly efficient for this purpose. One half gram of rotenone was dissolved in 100 cc of benzol and approximately 1 cc of the mixture injected into the opening of each cyst. This method of treatment is relatively fast as compared with any other treatment applied to grubs individually.

Studies concerning the types of soil which are unsuitable to the further development of cattle grubs after they drop from the animal have been continued.

A careful study and recheck of certain points in the life history of cattle grubs was made which demonstrated that there are only three stages in the larval life of the insect, instead of five as formerly believed. The third stage is more vulnerable to insecticidal treatment than the second.

HORSE BOTS

Biological studies of horse bots have been continued. The finding by a foreign entomologist that the first stage of the common bot spends some time burrowing in the tongue of the horse before going to the stomach has been confirmed. The period spent in the tongue has been determined as approximately 1 month. This has an important bearing on the control of bots by treatment of the horse's stomach with a fumigant. To avoid reinfestation of the stomach from the tongue, all eggs on the hair of the animal should be destroyed 30 days before the stomach treatment is given, unless such treat-

ment is delayed until such time in the winter as will make certain that all eggs have been dead at least 30 days because of cold weather. It was determined that the date of last occurrence of larvae in the tongues of horses at Ames, Iowa, in 1933 was about the middle of January. This indicates that in that section ovicidal applications may be omitted in bot-control campaigns in cases where the internal medication is applied after the middle of December.

THE USE OF BLOWFLY MAGGOTS IN SURGERY

Surgeons continue to report splendid results from the use of maggots in the postoperative treatment of osteomyelitis and other infected wounds. A number of different phases of maggot production and utilization in surgery have been under investigation in cooperation with several hospitals where this treatment is employed. Special attention has been given to ways of reducing the cost of maggot production. A simplified technic has been developed which makes it possible greatly to speed up the sterilization and handling of the eggs. This is a definite step in the direction of making the maggot treatment more generally available to those suffering with osteomyelitis and other diseases. The high cost has been one of the chief barriers to more wide-spread use of this treatment.

In studying the means by which maggots bring about the rapid healing effects in the wound, it has been found that the principal factor involved is probably the extensive removal by the maggots of the dead and diseased tissue from the wound, and the destruction by them of the disease-causing bacteria.

Several articles bearing upon the results of this investigation have been published during the year, or are now in press.

RAT MITES AND TYPHUS FEVER

During the year a considerable outbreak of typhus fever occurred in Crystal City, Tex., and neighboring towns. An examination by a member of the field-station staff located at Uvalde, Tex., revealed the fact that the area in that vicinity was heavily infested with rat mites. The scourge of rats, and to some extent the mites, extended as far north as Uvalde and Sabinal, Tex., but no cases of fever occurred in these towns. This situation was taken over by the Bureau of Biological Survey and health officials and the rats were brought under control, which resulted in the control of the mites.

TICKS

The occurrence in many States throughout the country of the tick-borne disease of man known as Rocky Mountain spotted fever has given impetus to investigations of ticks, especially the American dog tick (*Dermacentor variabilis* Say) and other species which attack man. In cooperation with entomologists throughout the country and field workers in the Bureau of Biological Survey and the Forest Service much information on the distribution, hosts, and seasonal abundance of ticks has been obtained. In the vicinity of Washington, D.C., where many cases of this disease with a relatively high mortality have occurred, the tick vector has received special study. It has been found that the small rodents, particularly field mice, white-footed mice, and pine mice, serve as hosts for many of the larvae and nymphs. To a slight extent these immature stages engorge with blood upon squirrels. Rabbits are of less importance, and fortunately birds do not appear to serve as hosts at all. Where they occur, coyotes, foxes, opossums, raccoons, skunks, and others of the larger wild animals have been found to harbor the adult ticks. However, dogs play a much more important part in the engorgement of the adult ticks than any other host. Horses, cattle, and goats are of secondary importance in this respect. The close association of dogs with man makes them of paramount importance in connection with the disease. The application of ground derris powder or the hand picking of the ticks from dogs is being recommended. The use of the powder at weekly intervals gives satisfactory control, but hand picking has to be carried out at intervals of 4 days to prevent dropping of engorged ticks. The occurrence of the mice which serve as hosts, in close proximity to habitations and to roads and other places frequented by man, makes their destruction a matter of importance. Methods of controlling them have received consideration in cooperation with the Bureau of Biological Survey. The importance of preventing tick attachment to man by frequent exami-

nations of the body, by wearing special clothing, and by using repellents, has been emphasized to the public.

The brown dog tick (*Rhipicephalus sanguineus* Latr.), which is a severe pest of dogs in Texas and Florida, has become established in many northern localities through introduction on dogs from the South. These infestations in the North have been found to persist through the winters in heated houses. This tick is a very annoying household pest. The use of derris and derris derivatives on the dogs and in their sleeping places combined with insecticidal sprays on the walls of the infested rooms has given good satisfaction.

In the cattle-tick-eradication work in Florida the Bureau of Animal Industry has found that in certain areas the tick does not yield to the usual program of dipping or vacating of pastures. This was thought to be due to the extensive occurrence there of the tropical variety of the cattle tick, *Boophilus annulatus australis* Fuller, and the abundance of certain wild animals, particularly deer, which serve as hosts. The situation called for a review of the hosts, life history, and longevity of this variety of the cattle tick under Florida conditions, and such a study was begun at the request of and in cooperation with the Tick Eradication Division of the Bureau of Animal Industry. Deer were found to harbor considerable numbers of this tick but no other hosts have been found among the wild animals and birds thus far examined.

DEVELOPMENT OF FLY-SPRAYING MACHINES

The object of this study, reported here for the first time, but which has been pursued intermittently for the past several years, was to develop adequate machines for applying sprays to kill or repel flies which infest dairy cattle. At present there are no satisfactory machines on the market with which dairy cattle can be sprayed successfully. Their inefficiency lies in the fact that they either spray too large a volume of liquid, which is costly and also burns the cattle, or they spray a fine mist, which is diluted with such a quantity of air that it is not effective. The air blast also has a tendency to frighten the flies away before enough of the spray material has been applied to them. Another disadvantage of machines now on the market is their form of spray distribution, which does not have the correct break-up, throw, spread, and regularity.

During the past year various changes have been effected in the details of machines made previously. Tests have been carried out to determine the performance of various combinations of spray disks, basal disks, and pressures when used on the hand sprayer and the portable sprayer. From data thus secured the correct combination can be made for certain results desired, such as throw, spread, and rate of flow.

A high-pressure hand sprayer has been constructed which is a modified form of one made in 1931. It is smaller and easier to handle, but has a relatively higher pump pressure. A portable high-pressure sprayer has likewise been completed which is very promising. It embodies such desirable features as high pressure, long range, and wide distribution, a fine break-up and even spread. It is light and portable and may be operated by one man.

BEE CULTURE

The Division of Bee Culture is under the direction of James I. Hambleton with headquarters at Somerset, Md., and has three field laboratories—the intermountain laboratory, maintained in cooperation with the University of Wyoming, Laramie, Wyo.; the southern laboratory, maintained in cooperation with the University of Louisiana, Baton Rouge, La.; and the Pacific coast laboratory, maintained in cooperation with the University of California, Davis, Calif.

The work of this division covers all phases of apiary management and honey and wax production, and also the use of bees as aids to crop production in their role as cross-pollenizers of many plants.

DISEASES OF BEES

Laboratory investigations indicate that the causative organisms of European foulbrood and parafoolbrood, diseases of the brood of bees, are closely related, morphologically unstable, and difficult to differentiate in the vegetative stages. For many years "*Bacillus pluton*" has been considered the causative organism in the former disease and *B. alvei* a secondary invader. It is now apparent,

however, that *B. alvei* is the causative organism in European foulbrood and that the so-called "*B. pluton*" is nothing more than a mutant or variant of the parent organism. The verification of this fact lends considerable hope to the possibility of untangling factors, of which little is known, concerned in the spread of this disease.

Bacillus para-alvei, the causative organism in para-foulbrood, apparently has a life history similar to that of *B. alvei* in that under special cultural conditions the rod and spore stages produce mutants differing greatly in morphological and cultural characteristics from the parent stage. No new outbreaks of this disease, first discovered 3 years ago, have been reported. Apparently infection is still confined to Florida, Georgia, North Carolina, and South Carolina.

Since 1931 a total of 200 samples of commercial honeys have been examined for the presence of spores of *Bacillus larvae*, the cause of American foulbrood. Special laboratory technic has shown the presence of spores in 16, or 8 percent, of the samples. As a further check and in order to determine whether any of the 16 samples contained enough spores to produce disease, the samples were fed to isolated healthy colonies, the result being that only one colony contracted the disease. It may be assumed from these results that commercial honey plays a minor part in the spread of the disease, and that under present conditions of control and of the continued spread of American foulbrood certification of honey as to its freedom from contact with American foulbrood, as required by certain States, is not justified.

ECONOMIC STUDIES

One of the most comprehensive economic surveys ever made of beekeeping has just been concluded on the Pacific coast. This work was done cooperatively with the University of California; and although the data refer largely to California, certain economic aspects of the beekeeping industry of the entire United States have been included.

An outcome of this study in relation to honey marketing in California indicates that the market for honey can be greatly improved by the adoption of grades and standard containers, through cooperation of producers.

A study of honey production in Oregon has shown that when yield was below 30 pounds per colony the cost of production (1931) was 13.3 cents per pound. This cost gradually decreased, reaching 4.5 cents per pound with a production of 90 pounds per colony or over. Based on the records of 85 co-operators whose apiaries yielded surplus honey ranging from 22 pounds to 115 pounds per colony, the average cost of production (1931) was 6.4 cents per pound.

TECHNICAL STUDIES

Beginning with 1932 the percentage of successfully inseminated queens has been higher than in previous years. Out of 135 queens, 65 laid worker eggs, and of these 20 gave evidence of being fully inseminated. The results so far in 1933 have been even more satisfactory than in 1932.

Queen breeders often complain of heavy losses of queen cells. In the spring of 1933 a similar difficulty was encountered in the breeding yard at Somerset, Md., the cause being attributed to a severe attack of sacbrood, a virus disease of the brood. From 1,730 larvae transferred in 1933, 242 queens were produced, whereas in 1932 from 2,545 larvae 652 queens were raised. During 1932 three successive generations of certain strains were reared, and the same is true of 1933. Three different strains were successfully wintered over and have already been carried through three generations this season. These strains are being bred to establish pure lines, and careful biometric measurements are being made and kept up to date so that the results of each mating are known soon enough to afford an index of what is being accomplished. As an aid to this work a careful study has also been made of the results of natural queen mating in flight in the open.

Biometrical measurements have been made of the progeny of various queens in a study of the variation which occurs under identical conditions. It has also been possible to study the seasonal variation in the progeny of a single queen.

Premature supersedure or "mortality" of queens is a problem that has given queen breeders and purchasers of package bees and queens a great deal of concern. Preliminary work has been started in an effort to learn

the causes for early or abnormal supersedure and if possible to find a remedy. As an illustration of the high mortality that often occurs, 30 queens were shipped to the University of Wisconsin and introduced. Seven died in the cages during introduction, five were not accepted after introduction, and one queen was immediately superseded. This is an unusually high mortality, but illustrates what may happen in certain seasons under certain conditions.

It was found desirable to make a study of the weight per gallon of the various honeys produced in the United States, since it has been found that 12 pounds per gallon, the standard heretofore considered as correct, was too high. The result is that recommendations have been made for the adoption of 11 pounds 12 ounces as the minimum weight per gallon for honey under the United States grades. A number of methods have been worked out by which the weight per gallon of honey may be determined with fair accuracy and without expensive equipment.

A series of honeys from various floral sources was heated (approximately 1 hour at 140° F.) long enough to melt all the crystals, and cooled quickly. These were then divided into groups and subjected to varying temperature changes. The following honeys showed no indication of crystallization even though a sample of each has been kept in each of the four temperature compartments: Buckwheat, tuliptree, sourwood, tupelo, buckeye, fireweed, gallberry, and white clover.

COLONY-BEHAVIOR STUDIES

Detailed studies of changes in colony populations, brood rearing, honey production, honey consumption, pollen gathering, winter death rate, etc., are being made on isolated colonies. Using 12 colonies a correlation coefficient of 0.9219 ± 0.0149 was found between population and production. These colonies produced an average of 120 pounds of honey, the strongest producing 180 pounds. With colony populations of from 15,000 to 45,000 the production factor per thousand bees gradually increased with an increase in population, at 15,000 being 1.33 per thousand while at 45,000 it was 2.3 per thousand.

Bees emerging and working during the active season varied in length of life, on an average, from 22 to 48 days, the majority having an average life of about 5 weeks. Marked bees which emerged between August 23 and October 1 remained in the colonies in appreciable numbers until the end of June 1933, a period of 8 or 9 months. The average mortality during the winter was approximately 2.4 percent per month. Bees making up the winter cluster did not die numerically according to their age, nor was there any systematic distribution of bees according to age in the different parts of the winter cluster. This indicates a lack of division of labor among bees of different ages in the maintenance of the winter cluster. Many beekeepers in the Inter-mountain region attribute winter losses to the inability of bees to utilize granulated stores. Three experimental colonies having only solidly granulated honey wintered normally, indicating the probability that granulated honey in itself is seldom responsible for winter losses. Brood rearing during the winter has generally been considered abnormal and detrimental to successful wintering. With this in mind a series of colonies were provided with sugar or honey alone and others with honey, and varying quantities of pollen. This experiment indicated a very much greater survival of bees receiving pollen than of those wintered on sugar alone, the greatest survival going with the largest amount of pollen. These tests strikingly indicate that brood rearing during the winter and early spring can be of great value and that a reserve of pollen for this somewhat out-of-season brood rearing may be highly desirable.

A final test was made of the effect of flight range upon honey production. An apiary of 30 colonies was so located as to be entirely surrounded by at least 1 mile of sweetclover, while another 30-colony apiary was located in the Bad Lands $1\frac{1}{2}$ miles from any sweetclover. The inner apiary made an average net increase of 261 pounds per colony as against an average of 207 pounds per colony for the outer apiary. While these results do not check with similar experiments in which a smaller number of colonies have been used, they indicate that a good crop of honey can be obtained even though the bees may be located some distance from the source of nectar.

IDENTIFICATION AND CLASSIFICATION OF INSECTS

Investigations on the taxonomy of insects in the Division of Insect Identification and Classification have continued under the direction of Harold Morrison.

As heretofore, the greater portion of the time of the specialists of this unit has been used in making identifications of specimens submitted by other offices of the Bureau and Department, State experiment stations, etc.—a service essential to all phases of entomological work. Many of the specimens received for identification were submitted by the Bureau of Plant Quarantine. There has been a definite increase in the amount of material submitted for determination. The numbers of identifications for the year total 27,416, an increase over the previous year of approximately 6.5 percent.

In spite of the demand for identifications, some original scientific work in insect classification has been completed and offered for publication through appropriate scientific and technical channels within and outside of the Department. Three significant contributions dealing with economic groups are to be published as technical bulletins. One of these is a revision of a group of leaf hoppers, another deals with the hymenopterous parasites of the hessian fly, and the third with the biology and classification of fruit flies native to Florida.

The investigations required in making identifications develop important facts on the occurrence and distribution of insects. Studies during the year showed that the anobiid beetle breeding in stems of ivy in Roanoke, Va., is a European species, *Ochina ptinoides* Marsh., and that a European weevil, *Brachyrhinus ligustici* L., had recently been collected at Oswego, N.Y. Many larvae of a chrysomelid beetle, *Exosoma lusitanica* L., which is a potential pest of bulbs, were submitted for identification following interceptions in Cipollina bulbs from Morocco. A weevil responsible for considerable injury to onion and garlic in Texas proved to be a native species, *Ceutorhynchus tau* Lec., which has remained unknown since initially described. Studies to define the characters which would distinguish certain noctuid moths of the genus *Heliothis* cleared up a number of uncertain points and demonstrated that the report of the occurrence in this country of the European species, *dipsacea*, is without foundation. Research on a related group of moths established the fact that one of the pests of peppers which caused the rejection of shipments of this vegetable from Mexico was identical with a species rather generally distributed throughout the Southwest but recorded under another name.

INSECT PEST SURVEY AND PUBLIC RELATIONS

This work has continued under the direction of J. A. Hyslop.

INSECT PEST SURVEY

During the past year the insect pest survey has issued monthly reports on current insect conditions for the information of Federal and State entomologists and others associated with entomological work. These reports are based on collaboration with such official and other entomologists of the United States and its insular possessions and also of Canada, Mexico, Guatemala, Costa Rica, Cuba, Haiti, and Brazil. From its records it has furnished specific information for the use of the personnel of this Bureau and of the Bureau of Plant Quarantine and to entomologists in the several States and others in interest. The records of the survey now include notes on over 27,000 species of insect pests in nearly 11,000 genera.

PUBLIC RELATIONS

The public-relations feature of this office concerns three subject-matter specialists in entomology who work in cooperation with the extension personnel in the several States.

In connection with the very severe grasshopper outbreak in the northern Plains States, one of these specialists has for the past two seasons spent considerable time in aiding the control campaign in North Dakota. This season (1933) he organized largely the work in this State in 36 counties with the result of an indicated saving of crops to the value of about \$2,000,000.

This service has rendered material aid, also, in securing the adoption of the new spray services and schedules for tree fruits in several States. In two States special assistance and demonstrations were given to train State leaders in the preparation and use of chemically treated bands for supplemental codling-moth control—a very valuable means recently developed by the Bureau.

Another important feature of this extension service has concerned the adoption of measures developed by the Bureau for the control of bots in

horses and mules—a type of injury which has been on the increase. Over 300,000 horses and mules in seven States have been treated as a result of the activities of these specialists. In Illinois alone this work has concerned 136,000 horses, or 1 out of every 6 horses in the State.

Similarly, cattle-grub control has been stimulated and aided in Illinois, Iowa, and Missouri by discussions at meetings and other types of publicity.

These agents have also cooperated in aiding educational features at boys' and girls' 4-H club camps to give these prospective farmers and home makers information on entomological problems.

Similarly, film strips on entomological subjects have been utilized in many States and assistance has been given in the preparation of motion pictures.

Another activity of this work has been the preparation of exhibit material, and particularly the preparation of exhibits for the Century of Progress Exposition.

INSECT PHYSIOLOGY AND TOXICOLOGY

The work on insect physiology and toxicology, under the direction of Frank L. Campbell at the Takoma Park (Md.) laboratory, is concerned primarily with basic investigations of the reaction of insects to poisons. An important phase of the work is the testing of new insecticides developed by the Bureau of Chemistry and Soils. These tests of many different substances and compounds cannot, under space limitation, be here given detailed consideration. Special mention, however, should be made of the investigation of derris root and its derivative, rotenone, in various combinations and in relation to different types of insects. Studies have also been made of nicotine, of acetone extracts of various plants, and of synthetic organic compounds, against mosquito larvae. None of these tests with mosquito larvae has so far shown much promise. Other series of tests have had relation to stomach poisons for leaf-feeding insects.

As bearing on studies of poisons, attractants, etc., technical studies of the sense organs and of the physiological and metabolic activities of insects have been continued.



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